Materials
in Design Engineering

value engineering & materials

Here's a new economical high-strength copper-nickel-iron alloy from

ANACONDA

Cupro Nickel, 30%-707 . . . is Anaconda's answer to design needs for an economical copper-nickel-iron alloy with mechanical properties to match those of more expensive metals. This high-strength, corrosion-resistant alloy is the product of an intensive three year metallurgical research and development program at Anaconda.

Cupro Nickel, 30%-707 . . . was especially designed for heat exchanger tubes in power station feedwater heaters. In this application, it provides performance as well as cost advantages. Typical test results show room temperature tensile strengths of 84,700 psi (⅝-inch O.D. tubes with 0.049-inch wall) and 88,000 psi (¾-inch O.D. tubes with 0.049-inch wall).

Cupro Nickel, 30%-707 . . . is finished with a special stabilizing anneal to permit tight U-bends and strength retention at elevated temperatures. The material can withstand a working stress in tension of 15,200 psi at 600 deg. F. In addition, it has high resistance to stress-corrosion cracking and excellent resistance to corrosion by sea water at relatively high velocities.

Cupro Nickel, 30%-707 . . . is adaptable to diversified design requirements. It can be cold worked and welded, used in tube sheets or for bolts and screws. It may be the alloy you need for engineering designs requiring strength, ductility, and corrosion resistance. Mechanical properties are competitive with "premium" high-strength alloy materials; cost is substantially lower. Complete details on high-strength Alloy 707, including a point-by-point comparison, are available in Anaconda Publication B-45. Write for your copy today. Address: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

61-925

ANACONDA
AMERICAN BRASS COMPANY

For more information, turn to Reader Service card, circle No. 341

NOVEMBER, 1961 | VOL. 54, NO. 6

Materials in Design Engineering®

FORMERLY MATERIALS & METHODS

APPLICATION OF METALS, NONMETALLICS, FORMS, FINISHES

WILLIAM P. WINSOR
PUBLISHER

H. R. CLAUSER
EDITOR

JOHN B. CAMPBELL
MANAGING EDITOR

ROBERT J. FABIAN
ASSOCIATE EDITOR

DONALD PECKNER
ASSOCIATE EDITOR

MALCOLM W. RILEY
ASSOCIATE EDITOR

JOHN A. MOCK
ASSISTANT EDITOR

ALFRED W. YOUNG
ASSISTANT EDITOR

WALTER LUBARS
EDITOR, MATERIALS SELECTOR ISSUE

M. RANDOLPH LONG
ADVERTISING SALES MANAGER

JOHN Y. CUNNINGHAM
RESEARCH & PROMOTION MANAGER

DAVID N. WHITCOMBE
CIRCULATION MANAGER

SUE FELDMAN
SUBSCRIPTION MANAGER

JOHN A. KOVCHOK
PRODUCTION MANAGER

WILLIAM SCOLLON
ADVERTISING PRODUCTION MANAGER

E. M. WOLFE
MANAGER, READER SERVICE

PUBLISHED BY
REINHOLD PUBLISHING CORP.
430 PARK AVE., NEW YORK 22, N. Y.

RALPH REINHOLD, CHAIRMAN OF THE BOARD
PHILIP H. HUBBARD, PRESIDENT & TREASURER
K. A. STARKE, SECRETARY & ASST. TREASURER
DONALD HOAGLAND, VICE PRESIDENT
MERALD LUE, VICE PRESIDENT
F. P. PETERS, VICE PRESIDENT
D. BRAD WILKIN, VICE PRESIDENT
WILLIAM P. WINSOR, VICE PRESIDENT

PRICE FIFTY CENTS PER COPY, EXCEPT MID-OCTOBER ISSUE NOT SOLD SEPARATELY. PAYABLE IN ADVANCE, ONE YEAR, $3.00; TWO YEARS, $5.00 IN U.S., U.S. POSSESSIONS AND CANADA. ALL OTHER COUNTRIES: ONE YEAR, $15.00; TWO YEARS, $25.00 (REMIT BY NEW YORK DRAFT). ABOVE RATES APPLY ONLY TO INDIVIDUALS DIRECTLY INVOLVED IN THE APPLICATION AND SELECTION OF METALS, NONMETALLICS, FORMS AND FINISHES. ALL OTHERS: SUBSCRIPTION RATES ON REQUEST. PUBLISHED MONTHLY, WITH AN ADDITIONAL ISSUE IN MID-OCTOBER. PRINTED BY PUBLISHERS PRINTING-ROGERS KELLOGG CORP. INDEXED REGULARLY IN ENGINEERING INDEX AND APPLIED SCIENCE AND TECHNOLOGY INDEX. ESTABLISHED IN 1929 AS METALS AND ALLOYS. TITLE CHANGES: MATERIALS & METHODS IN 1945, PRESENT TITLE IN 1957. **POSTMASTER**: SECOND CLASS MAIL PRIVILEGE AUTHORIZED AT NEW YORK, N. Y. SEND FORM 3579 TO MATERIALS IN DESIGN ENGINEERING, 430 PARK AVE., NEW YORK 22, N. Y. **SUBSCRIBERS**: SEND SUBSCRIPTION CORRESPONDENCE AND CHANGE OF ADDRESS TO MATERIALS IN DESIGN ENGINEERING, 430 PARK AVE., NEW YORK 22, N. Y., GIVING OLD AS WELL AS NEW ADDRESS, AND INCLUDING CITY POSTAL DELIVERY ZONE. IF POSSIBLE ENCLOSE LATEST ADDRESS LABEL. ALLOW TWO MONTHS FOR CHANGE.

COPYRIGHT, 1961, REINHOLD PUBLISHING CORPORATION. ALL RIGHTS RESERVED.

What's New in Materials

At a Glance 5

New Stainless Steel for Cold Heading 9
Has low work hardening rate . . . costs no more than type 305

Economical Rubber Resists Heat, Ozone, Weather 10
Ethylene-propylene synthetic is lightweight, good dielectric

Refractory Cements Good up to 5300 F 12
Air-dry and firing types available for sealing, bonding, potting

Sandwich Structures Joined with Low Weight Penalty 13
New method ignites an exotherm material at the bondline

Fine Mesh Cloth of Refractory Metals 15
Weaves as fine as 350 × 2300 can be made with very fine wire

Other Contents 163

Materials Engineering & Design

At a Glance 109

Value Engineering 111
Introduction to a systematic way to cut your materials costs

Epoxies Save Time, Money in Electronics 116
Why Motorola uses them for housings, casings . . . and a camshaft

Ultra High Temperature Textiles 117
A progress report: filling the gap between 500 and 2000 F

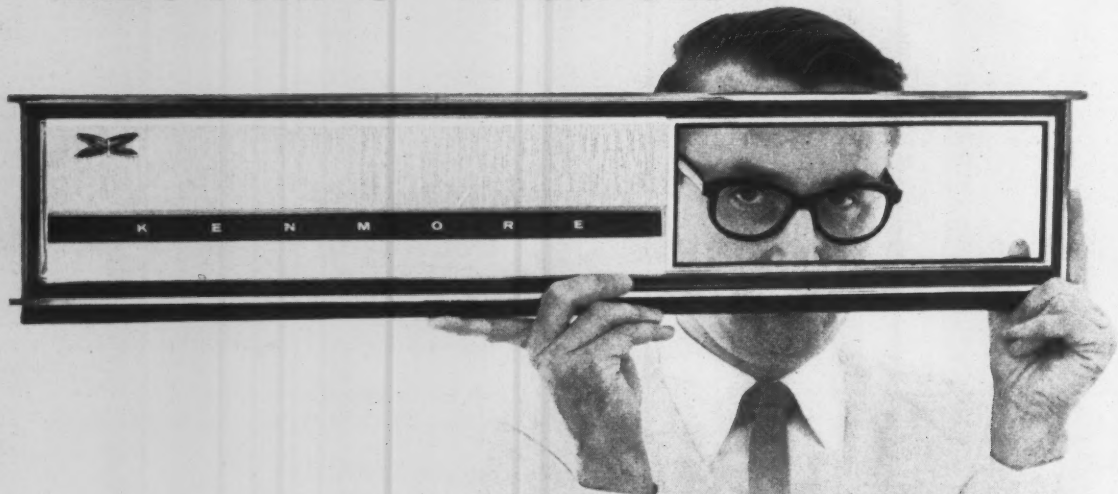
Specifying Tubing for Cold Forming 124
Here are eight properties and fabricating steps to think about

Other Contents 145

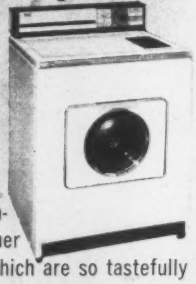
SPECIAL REPORT NO. 189
Progress in High Temperature Coatings 127
Five articles on plasma arc, diffusion, ablation, other methods

CONTINUED ON PAGE 3 →

"Are you getting your metal's worth?"



Beauty is only skin deep—but you've got to have the right kind of skin to begin with. Take this stylish zinc die cast control panel housing used on the Kenmore combination washer-dryer. Without the castability of Zamak you wouldn't be able to achieve the detailed decorative design and lettering cast in the smooth surface. And only the surface of a zinc die casting enables you to draw on the wide variety of finishing techniques—chrome plating, gold lacquer and white and charcoal enamel—which are so tastefully combined. • This panel housing is not a fragile beauty either. It has to be strong to endure a life filled with daily vibrations as the family laundry gets done. Design and production men are not easily charmed—they tried an anodized aluminum stamping—but they found it "too flimsy and not sharp looking." So much for that romance. • There are also some attractions related to this panel which are more than skin deep—the beauties of high production and interchangeable parts. Du-Wel Metal Products of Bangor, Michigan can consistently turn out up to 3000 of these castings a day, with variations in the right control box for different models of the washer-dryer. • **Remember—Zamak gives you more for less. Are you getting your metal's worth?**



NJZ

HORSE HEAD PRODUCTS

THE NEW JERSEY ZINC CO.

160 FRONT STREET • NEW YORK 38, N. Y.

For more information, turn to Reader Service card, circle No. 484

CONTINUED FROM PAGE 3

News of Industry

Plastics Institute Setting Its Course 17
Metal Joining Symposium 17
Copper Seeks Structural Uses 19
Metal Powder Testing Revised 19
News of Societies 19
Coming Meetings 21

6th Annual Awards Competition 27
Rules and entry blank. Deadline: Jan. 15, 1962

Reader Service 41

Technical Literature

Suppliers' New Literature 43
Books 49
Reports 50

File Facts

Corrosion Resistance of Electroless Nickel Coatings 141

Prices & Supply

At a Glance 143

The Last Word

Value Engineering: What Is It and Who's It For? 212

Other Departments

Letters to the Editor 23
Advertising Indexes:
Products Advertised 210
Advertisers 210

NEXT MONTH

Columbium: A Bright Future But How Soon? ... An up-to-the-minute status report on what promises to be an important engineering metal in the years ahead. It features a rundown of all alloys—commercial and developmental—and summarizes existing information on welding and fabrication.

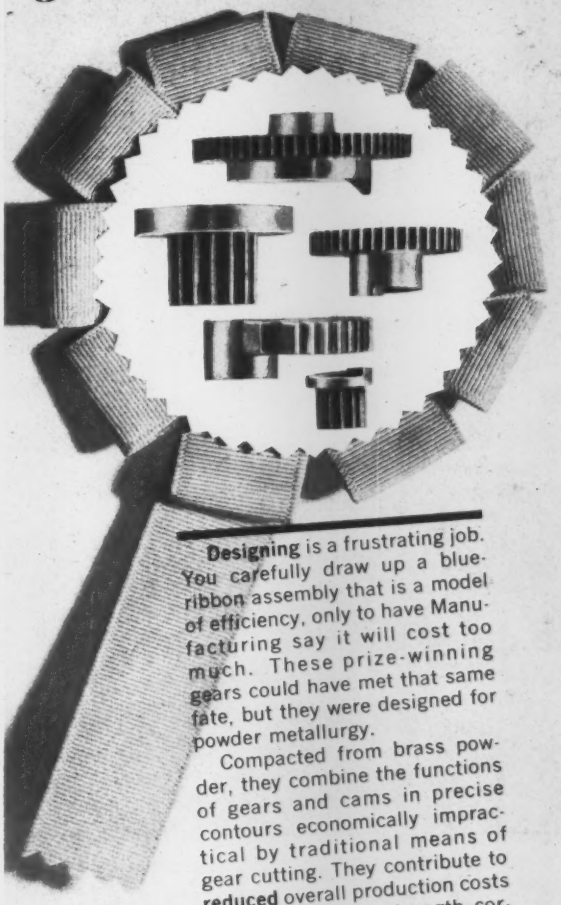
Allylic Plastics ... Once specialties for electronic use, these have become a large family of broad usefulness. The article takes a look at moldings, laminates, coatings and decorative overlays.

Solders for 250 F ... Data on tin-antimony solders which are becoming important as the operating temperatures of electrical equipment get too high for tin solders.

Two Important Materials Symposiums ... On-the-spot reporting of the technical highlights of two recent meetings: the Air Force's materials symposium in Phoenix, Ariz. and Picatinny Arsenal's symposium on adhesive bonding.

This Month's Cover: *Symbolic representation of cost cutting by Harry & Marion Zelenko.*

geared for success



Designing is a frustrating job. You carefully draw up a blue-ribbon assembly that is a model of efficiency, only to have Manufacturing say it will cost too much. These prize-winning gears could have met that same fate, but they were designed for powder metallurgy.

Compacted from brass powder, they combine the functions of gears and cams in precise contours economically impractical by traditional means of gear cutting. They contribute to **reduced** overall production costs while providing the strength, corrosion resistance, exact part to part duplication and absolute reliability necessary as the working mechanism of the S. H. Couch Co. fire alarm pull box.

Fabricated by American Sinterings Division of Engineered Plastics, Inc., they are the Grand Prize winners in the "Nonferrous Metal Powder Part of The Year" competition sponsored by New Jersey Zinc.

Avoid going back to the drawing board—design for nonferrous powder metallurgy. Write for your copy of "Designing For Pressed Brass and Nickel Silver Parts."

HORSE HEAD® ATOMIZED NONFERROUS METAL POWDERS ARE PRODUCED BY

THE NEW JERSEY ZINC COMPANY

160 FRONT STREET • NEW YORK 38, N. Y.

DEVELOPERS OF BRASS & NICKEL SILVER POWDERS SETTING TODAY'S STANDARDS

HORSE HEAD PRODUCTS

For more information, turn to Reader Service card, circle No. 471

This sidewalk is wired for snow

Nickel alloy electric heating cables in the concrete melt snow as fast as it falls!

No shoveling, no salting, no customer accidents on slippery sidewalks at *this* suburban branch of a Pittsburgh department store. Electric heating cables keep the sidewalks clear of snow and ice during even the worst winter weather.

Saves maintenance costs. In addition to taking the bother out of blizzards, the system eliminates the cost of conventional sidewalk clearance. And further savings are realized because the heating cables – made of 80% Nickel – require no maintenance.

High Nickel alloy cables were used because of Nickel's superior resistance to corrosion, fatigue and extreme temperatures. These Nickel alloy cables will withstand years of repeated heating and cooling, and seasonal expansion and contraction of the concrete.

Just one example of Nickel's versatility. Electric heating cables—also used to melt snow and ice from roofs and driveways – is another example of how Nickel helps make possible new products and processes, and improves existing ones. In most any application, Nickel's wide range of important properties . . . corrosion resistance, strength, long life and beauty, to name just a few . . . offers proven advantages.

If your business is metals, or if you use metals in your business, call on Inco for the latest information about how Nickel and its alloys can help you.

Imbedded near the concrete surface, electric heating cables of 80% Nickel keep the sidewalks clear of snow and ice. Cables made by Edwin L. Wiegand Company, Pittsburgh.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

A new series of columbium alloys can be fabricated without the usual need for high temperatures and inert atmospheres. In fact, the developer says the alloys can often be fabricated at room temperature. They are designed for use in the temperature range 1800 to 3000 F. First to be produced is a columbium-vanadium alloy that has excellent resistance to corrosion by liquid metals. It has moderate strength, and is easily fabricated and welded. (More details in next month's Special Report on columbium.)

Source: Westinghouse Electric Corp., Materials Mfg. Dept., P. O. Box 128, Blairsville, Pa.

An improved TFE packing material is said to be much less sensitive to the effects of operational and frictional heat, and more receptive to gland adjustment, than earlier grades. Improved performance is attributed to the complete removal of all carbonaceous material from the fiber by bleaching and preshrinking prior to braiding. The yarn sells for $18 per lb for 400 denier and $14 for 1200 denier.

Source: E. I. du Pont de Nemours & Co., Inc., Wilmington 99, Del.

Stamped and drawn parts from aluminum foil and sheet can be turned out faster by using a new water emulsion lubricant that requires no degreasing after forming operations. The devloper says that foil treated with the lubricant can be printed without difficulty. The lubricant is nonstaining.

Source: Fiber Products Research Center, Inc., Beaver Falls, N. Y.

A quartz paper for use from –459 to 3000 F is now available. Used by itself or impregnated with phenolic resins, the paper is recommended for a variety of ablation and heat shielding applications. It is supplied as sheets in thicknesses from 0.0015 to 0.085 in. and in widths from ½ to 84 in.

Source: C. H. Dexter & Sons, Inc., Windsor Locks, Conn.

Steel wire with random surface designs on it such as stars, crescents and oriental characters is designed for use in lamp stands, magazine racks, railings and other ornamental applications. Design depths range from 0.002 to 0.006 in. The cold drawn wire is supplied in a full range of carbon steels.

Source: Pittsburgh Steel Co., P. O. Box 118, Pittsburgh 30.

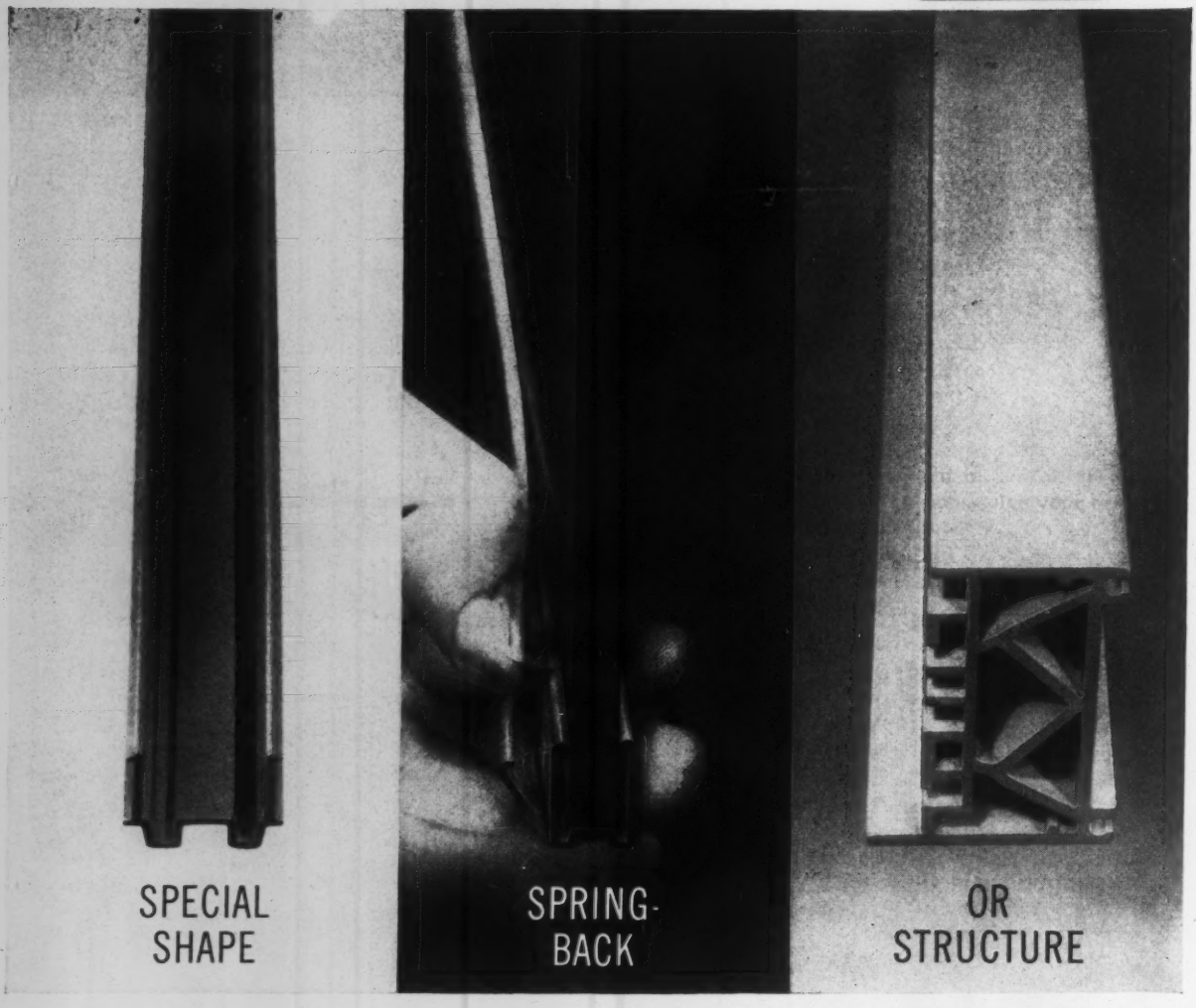
A new high impact grade of acrylic plastic has been added to a line of molding powders. It has an impact strength (notched, Izod) of 4.5 ft-lb per in. compared to 2.3 for the highest impact grade previously available from the producer. The new material is dimensionally stable, low in water absorption, resistant to staining, and odorless. It is sold in natural as well as in a wide range of colors.

Source: Rohm & Haas Co., Washington Sq., Philadelphia 5.

Faster machining of steel products is promised with the introduction of new tellurium-bearing steels by a number of steel producers. One company reports that its steel can be machined 3½ times faster than standard screw machine steel B1112. Another company says that a machined part that has to be knurled, shaved, grooved and tapped with two cross holes drilled can be made in 6½ sec with the

Each of these extrusions of rigid Geon by Crane Plastics, Inc., Columbus, Ohio, is in use for various architectural applications—chiefly windows. B. F. Goodrich Chemical Company supplies the rigid Geon vinyl.

B.F.Goodrich



Look how you can solve design problems with extrusions of rigid GEON vinyl

These extrusions show how the properties of rigid Geon lend themselves to solving different design problems. The special shapes show how detail can be reproduced—and it is easy to produce a long, smooth part, *straight* out of the die.

Other extrusions demonstrate how the springiness of thinner-walled extrusions gives you a spring-back characteristic for weather-stripping or rattle-proofing applications. Still others show the structural possibilities—how rigid Geon provides load-carrying strength without weight.

At the same time, each extrusion brings you all the other advantages of vinyl—unusual abrasion resistance, resistance to chemicals, self-extinguishing properties and electrical advantages. In every case there's the opportunity to mold color right in.

How can these extrusions solve your problems? We'd be glad to help you answer this question. Write Department NN-9, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio.
In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company

a division of The B.F.Goodrich Company

Geon VINYLS

For more information, turn to Reader Service card, circle No. 439

new steel compared to 12 sec for a comparable grade of leaded steel. (More details next month.)
Source: LaSalle Steel Co., 1420 150th St., Hammond, Ind.; Inland Steel Co., 30 W. Monroe St., Chicago 3.

Look for lower cost, more heat resistant nylon resins to make their appearance in the next few years. Reason: a new polymerization method has been developed whereby nylon can be produced at room temperature at a rate of several tons per minute. Resins produced by the technique generally have higher molecular weights and greater heat resistance than resins made by conventional melt condensation.
Source: M. Epstein, B. Bennett, Battelle Memorial Inst., 505 King Ave., Columbus, Ohio.

Pure cobalt strip with good ductility is now commercially available at $4.40 per lb. The strip is made from pure cobalt powder in a three-step process: 1) cold compacting, 2) sintering in a hydrogen atmosphere, and 3) hot rolling. It is sold in thicknesses ranging from 0.005 to 0.025 in. and in widths from ¼ to 6 in.
Source: Sherritt Gordon Mines Ltd., 25 King St. West, Toronto 1, Ontario, Canada.

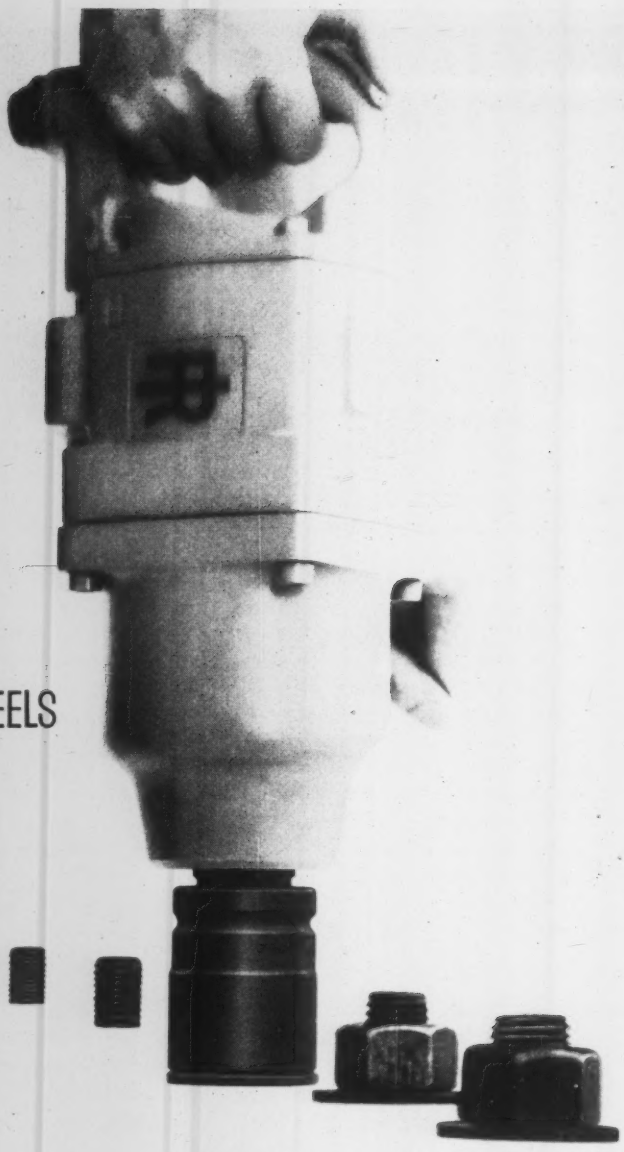
A new laminate can be stamped with permanent markings in the same die used for blanking and piercing, thus eliminating separate hot stamping, rubber stamping and silk screening steps. The stamped characters are said to have better abrasion and chemical resistance than conventional printed characters. The paper-phenolic laminate is recommended for terminal boards, coil ends, capacitor caps, labels, panels and spacers.
Source: Continental-Diamond Fibre Corp., Newark, Del.

An unmodified, one-part polyurethane coating is said to combine the advantages of oil-modified types (application ease, shelf stability and short drying time) with the desirable features of two-part systems (durability, and good physical and chemical properties). The coating is available in a hard version for use over wood, metal and glass and in a flexible version for soft plastics, fabrics, leather, paper and similar materials.
Source: Hughson Chemical Co., Div. of Lord Mfg. Co., Erie, Pa.

A new bronze bearing alloy containing large amounts of lead is specifically designed for self-lubricating bushings, bearings and seals. The alloy is sold as solid and hollow bars in diameters up to 5 in. and in standard 13-in. lengths. The bars, which are made by a continuous casting process, are said to be free of blowholes, shrinks, voids, pits and inclusions.
Source: American Smelting and Refining Co., 120 Broadway, New York 5.

The finest wire fabric yet woven has been made from superalloy wire 0.5 mil in dia. The wire has been spun into 7-filament yarns and 49-filament plied yarns and subsequently woven into low porosity fabrics on a hand loom. Porosity as measured by light transmission is as low as 0.1-2.5%. Such fabrics are being studied for use at temperatures of 1500-2000 F. (More details on high temperature textiles are given on p 117.)
Source: Fabric Research Laboratories, Inc., 1000 Providence Hwy., Dedham, Mass.

Turn to page 9 for more "What's New in Materials"



IMPACT STRENGTH OF
LEAD TREATED STEELS

TORTURE TESTED

3500 TIMES PER MINUTE

Switching to leaded* Aristoloy, Ingersoll-Rand was able to provide the high impact resistance (3500 per minute) and transverse strength required in these hammer case bushings. Use of leaded steel also cut machining time . . . eliminated tearing by the forming tool . . . extended tool life 10% . . . and shortened grinding time. Find out about these free machining lead treated steels—write for LEADED STEELS CATALOG today.

*Inland Ledloy License

ARISTOLOY STEELS

DIVISION OF
COPPERWELD
STEEL COMPANY

ARISTOLOY STEEL DIVISION 4021 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

For more information, turn to Reader Service card, circle No. 489

TENSILE STRENGTH VS COLD REDUCTION (1000 Psi)

Cold Red., % →	Ann.	10	30	50
Armco 18-19 LW	**78**	**88**	**117**	**152**
16 Cr–18 Ni	78	90	123	146
Type 305	78	95	135	170
Type 304	85	115	165	205

New Stainless Steel for Cold Heading

can cut materials costs up to 22%

■ A new low-work-hardening stainless steel alloy has been developed for severe cold heading, swaging and other cold forming applications. It is expected to be used for fasteners and related parts in automotive, aircraft, missile, chemical equipment and appliance applications where corrosion resistance is important.

Called Armco 18-9 LW, the new steel has the following composition: C, 0.10 max; Mn, 2.0 max; P, 0.045 max; S, 0.030 max; Si, 1.0 max; Cr, 17-19; Ni, 8-10; Cu, 3-4.

Fabricating properties and corrosion resistance are similar to those of Armco 16-18 (16 Cr, 18 Ni) which has a base price of $0.6025 per lb. The price of 18-9 LW, however, will be $0.47 per lb, equal to the base price of type 305 stainless steel. Armco Steel Corp., Middletown, Ohio, is the developer.

The material is available as billet, hot and cold finished bars, hot rolled rods and cold drawn wire.

Low work hardening rate

Armco 18-9 LW's low rate of work hardening permits severe cold heading or upsetting operations not ordinarily attempted with type 305 stainless steel, an alloy used in applications requiring moderate cold forming.

The rate of cold work hardening for 18-9 LW, compared with four other stainless grades, is as follows:

Grade	Work Hardening Factor
18–9 LW	84
16 Cr–18 Ni	84
12 Cr–15 Ni	84
Type 305	94/105
Type 304	126

The rate of work hardening compares favorably with those of alloys with higher nickel contents.

Of the steels listed above, type 305 has excellent corrosion resistance and can meet moderate fabricating specifications. The high nickel grades, also corrosion resistant, can be more severely deformed because of their lower work hardening factor.

Other factors favorable

The accompanying table shows how tensile strength of 18-9 LW varies with cold reduction, comparing it with three other stainless steels. Increased formability at a lower price is apparently achieved to some extent at the expense of strength, as the table shows. However, the designer who is using the higher nickel grades can lower his material costs 22% with no sacrifice in strength.

According to Armco, machinability of 18-9 LW approaches that of the free-machining grades.

Corrosion tests in salt spray fog, tap water, marine atmospheres, high humidity environments and 65% boiling nitric acid have shown that 18-9 LW is equivalent both to type 305 and Armco 16–18 stainless steels.

Corrosion resistant *fasteners of 18-9 LW stainless steel.*

For more information, circle No. 600

***Ozone resistance** is shown by comparison of SBR weather strip (top), which cracks after 3 min in 0.2% ozone. EPR, at bottom, was unaffected after 3200 min.*

Now commercially available here . . .

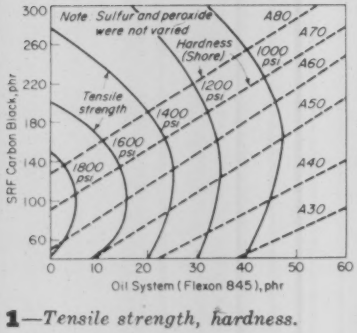
Economical Rubber

TABLE 1—MECHANICAL PROPERTIES OF TYPICAL EPR COMPOUNDS

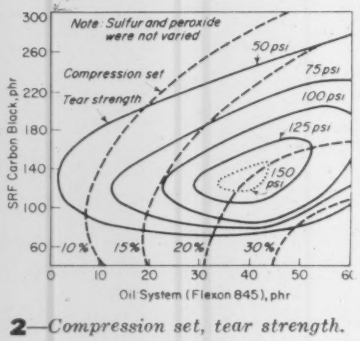
Effect of	Peroxides		Fillers		Carbon Blacks	
INGREDIENTS (phr)						
Enjay EPR (MD-460)	100	100	100	100	100	100
SRF Carbon Black	60	60	60	—	—	—
EPC Carbon Black	—	—	—	—	60	—
HiSil 233	—	—	—	60	—	—
Rega 300	—	—	—	—	—	60
Caci um Stearate	1	1	—	—	—	—
Sulfur	0.32	0.32	0.32	0.32	0.32	0.32
Dic umyl Peroxide	2.6	—	2.7	2.7	2.7	2.7
Luperco 130XL	—	2.86	—	—	—	—
Zinc Oxide	—	—	5	5	5	5
CE (min, °F)	30/320	30/360	40/320	40/320	30/320*	30/320*
PROPERTIES						
Tensile Strength, psi	1880	1930	1950	1780	3170; 3250	3200; 3160
Elongation, %	450	500	490	900	680; 680	620; 620
100% Modulus, psi	—	—	270	160	230; 180	240; 180
300% Modulus, psi	1200	1230	1160	250	860; 720	1120; 960
Hardness (Shore)	A58	A60	A62	A72	61; 57	60; 55

*First value is for press cure; second value for open steam cure.

Effect of carbon black and oil loading on . . .



1—*Tensile strength, hardness.*



2—*Compression set, tear strength.*

■ One of the most talked-about synthetic rubbers in years, ethylene-propylene copolymer elastomer is now commercially available in the United States. Exceptional ozone resistance, excellent electrical properties, good high and low temperature resistance, good stress-strain characteristics, chemical resistance and economy—these are the outstanding features of EPR now commercially available from Enjay Chemical Co., 15 W. 51st St., New York 19.

The low potential cost of the elastomer may well turn out to be its most outstanding attribute. Introductory price of the material as gum stock is 26¢ per lb. The low cost of the raw materials (ethylene and propylene) suggests that with development of volume markets, price could be substantially reduced.

Further, EPR is the lightest weight rubber available (specific gravity 0.86), so that it costs only about 0.8¢ per cu in. According to Enjay, EPR can be oil-extended or blackmasterbatched to the same extent as SBR and other general purpose rubbers.

Designated Enjay EPR (Grade MD-460), the material is said to be a completely amorphous, noncrystalline rubber. It is produced by Humble Oil & Refining Co. for Enjay. Vulcanization is carried out by a peroxide or a peroxide-sulfur system. Other methods are under development.

Electrical uses first

Electrical insulation appears to

Resists Ozone, Heat, Weathering

be the first major application Enjay is looking at for its rubber. This would include wire and cable insulation and jacketing, high voltage insulation, and molded rubber insulators. Other potential areas include extruded goods such as auto weather stripping where ozone resistance is important; also molded components, such as flexible coupling boots, appliance parts, auto parts, and bearing parts.

At present, the tack-free nature of the material in processing would make tire fabrication difficult although, based on its performance and cost potential, EPR would make a highly promising tire rubber.

Good strength, resilience

Being a noncrystalline rubber (similar to SBR), EPR has low gum tensile strength. However, it can be compounded and reinforced in the same way as other synthetic rubbers. Obtainable strengths are good, as shown in Table 1 which lists mechanical properties of various compounds, indicating effects of various peroxide curing agents, fillers and carbon blacks.

Relatively good mechanical properties are retained even after substantial oil extension, as the accompanying curves show. Fig 1 plots tensile strength and hardness obtainable with increasing carbon black and oil content; Fig 2 shows tear strength and compression set under the same loading conditions.

According to Enjay, ozone resistance of its EPR is essentially complete. For example, specimens require more than 53 hr to crack when extended 50% at room temperature in an 0.2% ozone concentration; under the same conditions a highly ozone resistant butyl rubber requires only 50 hr to crack and natural rubber only a few seconds.

Electrical insulating properties are excellent, as shown in Table 2. The combination of electrical properties with ozone resistance makes the material particularly promising for insulation applications.

Heat resistance is good, with a recommended maximum service temperature of abut 300 F. Table 3 shows effects of 72-hr aging at 300 F on mechanical properties of three typical compounds. At 350 F the material embrittles after about 48 hr exposure.

EPR is also reported to have fairly good low temperature properties. Tested by the Bell brittleness test, EPR has a value of −60 F, compared with −50 F for natural rubber and −35 for butyl.

Colorability of the material is said to be excellent. Although ultraviolet stability of black compounds is said to be excellent, weatherability of colored grades has not yet been evaluated.

Versatile in processing

EPR can be processed essentially by conventional rubber processing techniques, i.e., molding, extruding and calendering. Although at present no latexes are available, Enjay reports that production of EPR latexes by the same technique currently used for producing butyl latexes looks highly promising.

TABLE 2—PROPERTIES OF TYPICAL EPR ELECTRICAL COMPOUNDS[a]

Compound →	A	B
MECHANICAL PROPERTIES		
Tensile Strength, psi	800; 720	950; 1150
Elongation, %	740; 580	350; 440
100% Modulus, psi	320; 450	500; 640
300% Modulus, psi	500; 620	900; 1000
Hardness (Shore)	A65; 73	A71; 73
Compr Set (22 hr at 158 F), %	29	31
Ozone Res (time to crack in 0.2% ozone at rm temp), min	>400	>400
ELECTRICAL PROPERTIES[b]		
Vol Res, 10^{14} ohm-cm	1.21; 0.4	1.56; 0.8
Dielec Str, v/mil	1420; —	1155; —
Power Factor, %	0.66; 3.0	0.79; 3.2
Dielec Const	3.17; 3.3	3.34; 3.3

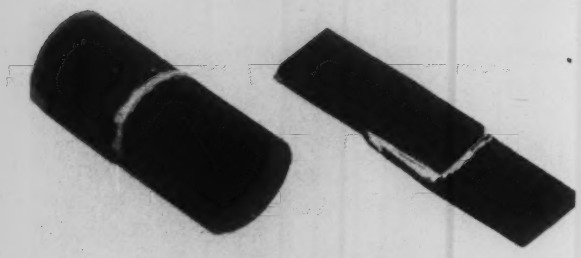
[a]Compounds cured 40 min. at 320 F; first value is as molded, second value is after 6 week immersion in water at 185 F.
[b]Frequency of 1 kc, at 77 F.

TABLE 3—EFFECT OF HEAT AGING ON TWO TYPICAL EPR COMPOUNDS[a]

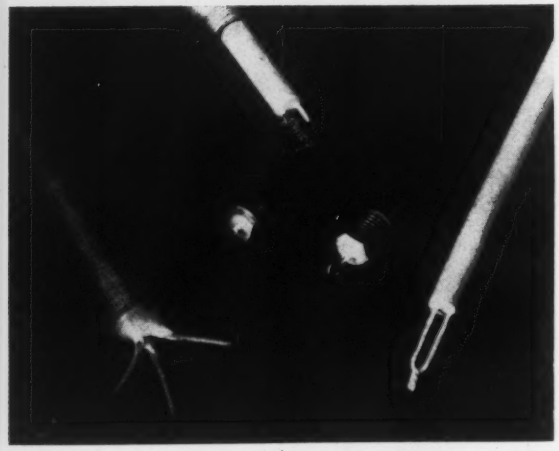
Compound →	A	B
Tensile Strength, psi	1800; 1650	1070; 860
Elongation, %	490; 620	240; 200
100% Modulus, psi	260; 260	550; 650
300% Modulus, psi	1200; 900	—
Hardness (Shore)	A68; 62	A75; 97

[a]First value as molded; second value after 72 hr at 300 F. Cured 30 min at 320 F.

For more information, circle No. 601



Bonding *of carbon, graphite and silicon carbide, as well as metals, can be securely accomplished with the cements.*



Sealing *such components as these, they can provide both electrical insulation and a hermetic joint.*

Refractory Cements

■ Recently developed ceramic cements, some of which can be air-set, feature 1) resistance to temperatures as high as 5300 F continuously, 2) excellent adhesion to ceramics, refractories, quartz and a variety of metals, 3) excellent thermal shock resistance, and 4) inertness to ceramics and metals with which they may be in contact.

Tradenamed Astrocerams, the materials are mixtures of oxides and silicates of IV-B elements (Ti, Zr, Hf), supplied premixed with liquid reagents. They can be used as high temperature adhesives, coatings or ceramic parts. The two basic types are: type A, which can be air-dried to provide a maximum use temperature of 4300 F, and Type B, which requires firing at about 2000 F to achieve bonds, but withstands temperatures as high as 5300 F. Low porosity types of each are also available.

Property data limited

Detailed property data are limited; the accompanying table lists the data available to date. Mechanical strengths are moderate; electrical insulating properties are quite good, tests indicate.

Chemically, the cements are soluble in hydrofluoric acid, but only slowly soluble in concentrated boiling sulfuric acid. They are insoluble in hydrochloric, nitric, phosphoric, and sulfuric acids at room temperature.

The cements are also resistant to carbon monoxide and dioxide, water, sulfur, arsenic, oxygen and hydrocarbons at temperatures over 1800 F. They react with carbon at temperatures over 3000 F.

Recent tests indicate excellent resistance to radiation.

PROPERTIES OF ASTROCERAM CEMENTS[a]

MECHANICAL PROPERTIES	
Mohs Hardness	8-9
Ten Str, 1000 psi	10-15
Compr Str, 1000 psi	80-150
Mod of Rupture, 1000 psi	23
PHYSICAL PROPERTIES	
Sp Gr	5-6
Coef of Ther Exp, 10^{-9} per °F	5-550
Ther Neutron Cross Section, barns	20-30
Ther Cond, Btu/hr/sq ft/°F/in	23.2
Max Continuous Svc Temp, F	3200-5300[b]
ELECTRICAL PROPERTIES	
Dielec Str, v/mil	200-300
Vol Res, ohm-cm	10^{13}-10^{15}
Dielec Const	
60 Cps	~9
10^6 Cps	7-9
Arc Res, sec	>500

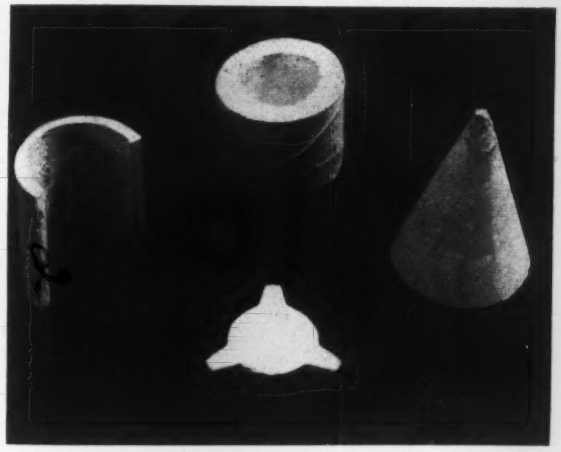
[a] Approximate data applying to all Astrocerams.
[b] Depends on type.

Dipping, brushing best

As coatings for metal foil, sheet or wire, or as adhesives for metal-metal, metal-nonmetallic, or nonmetallic-nonmetallic bonding, cements can be applied by dipping or brushing; spraying may be used in some cases, although premature drying may occur. For thick deposits, succeeding layers of thin coats, alternated with air-drying periods, are recommended. Drying must be carried out slowly to prevent porosity due to bubbling.

Metals to be bonded should be cleaned, and preferably mechanically roughened. If possible surfaces should be lightly oxidized.

Type A cements in thin sections (1/32 in. or less) should be predried at 120-150 F for 1 hr. According to reports, such air drying provides sufficient strength for some applications. For full cure, cements should be subse-



Casting or potting *can be simply accomplished using inexpensive cardboard molds.*

by K. W. Cornely, *Chief Ceramist, American Thermocatalytic Corp.*

Good up to 5300 F

quently heated (at a rate not exceeding 20 F per min) to 1100 F. Thicker sections require longer predrying and slower curing.

Type B cements, in thin sections, require predrying at 150-180 F for ½ to 1 hr, followed by curing at increasing temperatures (rate not to exceed 50°F per min) until temperatures reach 2200 F.

Potting, sealing, etc.

The cements have been used for bonding and encapsulating thermocouples, sealing wire ends, wire casing, as capacitor dielectrics, and for potting high temperature electronic components.

The cements have also been used for casting of welding and brazing fixtures, and for crucibles.

For more information, circle No. 602

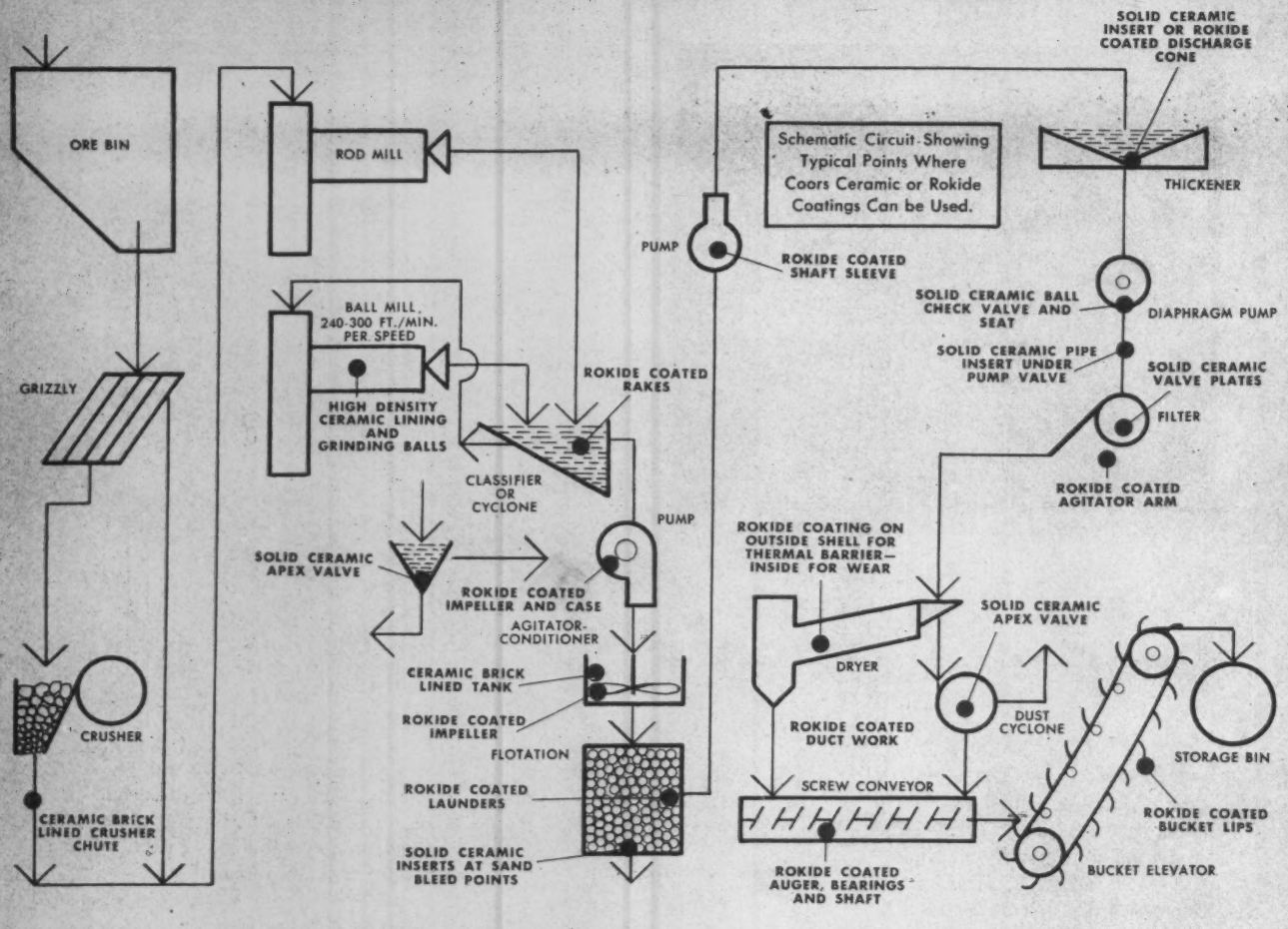
Sandwich Structures Joined with Low Weight Penalty

A unique new joining method known as "exo-flux" has been developed for joining high strength metal sandwich panels with little weight penalty.

Although process formulations and techniques have been developed specifically for ordinary stainless steels, the new process has produced effective bonds with most of the heat treatable stainless steels, including 17-7PH, PH15-7Mo, AM-350, AM-355, A-286, A-302 and A-321. There is some promise that the exo-therm method can also be used to bond high temperature alloys such as Inconel X and René 41, and even refractory metals such as molybdenum, tungsten and tantalum.

An important advantage of the exo-flux method (the name stems from combined use of exothermic heat and a fluxing agent) is that it adds relatively little weight to sandwich structures. Ordinarily, brazing adds about 0.3 lb per sq ft to the weight of sandwich panels. The new process only adds 0.006 lb per sq ft.

Preliminary details on the joining method were disclosed by F. W. Kuhn, G. P. Peterson and R. C. Tomashot in a paper on "Plastics, Adhesives and Composites Materials," delivered at the recent Materials Symposium in Phoenix sponsored by the Air Force Aeronautical Systems Div. The process uses an exothermic-reactant material which is applied to the external surfaces of metals to be joined. Ignition of the material instantly produces intense heat of short duration in a metal oxide fluxing agent and an element-donating material placed on the bondline. Under the spontaneous condition of firing, the metal oxide of the fluxing agent releases its metallic portion to form a eutectic with part of the base metal. Thus, a strong adhesive joint with a continuous metal phase is formed.



ALSO: MECHANICAL PUMP SEALS; MULLER WHEELS AND PLATE; METERING ORIFICES

Solve Wear and Corrosion Problems

Chemical and mineral beneficiation plants operate equipment under severe abrasive and corrosive conditions. This typical flowsheet shows how these people get maximum operating life by using Coors ceramic parts and Rokide* coated parts. Coors generally furnishes solid alumina ceramic parts to OEM. However, Coors offers Rokide* ceramic spray coating licenses and rods both to OEM and to users — you can do the Rokide* coating right in your plant, or use licensed applicators in your area. Take a look at your plant, see how Coors can help you solve critical abrasion or corrosion problems. Write for Technical Data Sheet 9000A, or call your nearest Coors regional sales manager: WEST COAST, *William S. Smith, Jr., EM 6-8129, Redwood City, Calif.*; MIDWEST, *John E. Marozeck, FR 2-7100, Chicago, Ill.*; CENTRAL, *Donald Dobbins, GL 4-9638, Canton, Ohio*; EAST COAST, *John J. McManus, MA 7-3996, Manhasset, N. Y.*; NEW ENGLAND, *Warren G. McDonald, FR 4-0663, Schenectady, N. Y.*; SOUTHWEST, *Kenneth R. Lundy, DA 7-5716, Dallas, Texas*; OIL FIELD INDUSTRY, *William H. Ramsey, UN 4-6369, Houston, Texas.*

Coors

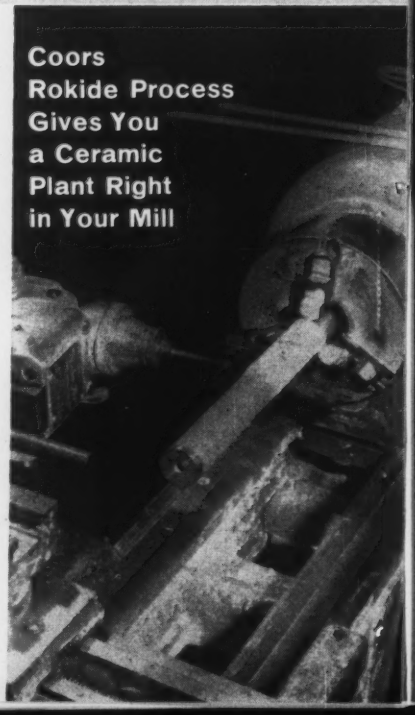
ALUMINA CERAMICS

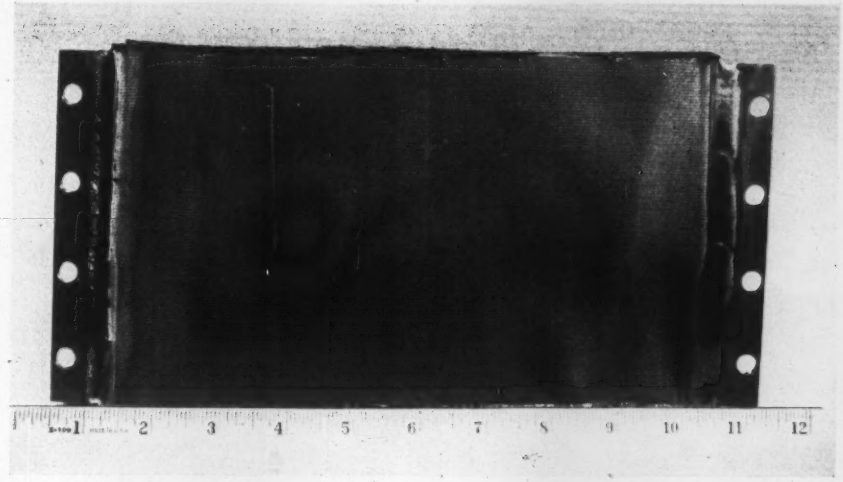
Coors Porcelain Company

600 NINTH STREET • GOLDEN, COLORADO

For more information, circle No. 492

*Rokide T.M. Reg. U.S.Pat.Off., Norton Co.





Ion emitter *consists of tantalum wire cloth in a twill weave, inert arc welded to a vapor duct. Cloth operates at 1800-2400 F in cesium vapor.*

Now it can be made:

Fine Mesh Cloth of Refractory Metals

by Dr. Guntis Kuskevics, *Flight Propulsion Laboratory, General Electric Co.*

■ Dense, fine mesh refractory metal cloth has now been woven as a result of the need for ion emitters for ion propulsion engines for space.

The Twill Dutch weave can be produced on standard looms using tantalum, columbium, molybdenum and tungsten with meshes up to 50 × 1000. With 0.6-mil wire, meshes up to 350 × 2300 can be produced in some materials.

Previously, square weave wire screens with meshes up to 400 × 400 had been produced for some time from monofilaments of tungsten, molybdenum, tantalum and other high temperature metals.

Tantalum most common

The cloth in the emitter operates at 1800 to 2400 F in cesium vapor which is ionized as it passes through the incandescent cloth. Although tantalum was finally selected to make the cloth, several refractory metals were evaluated because of their high work function, high melting point, and low vapor pressure. Most ionization data are available for tungsten. But tantalum, columbium and rhenium have the desirable electrical characteristics, are easier to machine, and do embrittle upon heating to incandescence.

Tantalum wire cloth was produced in either 20 × 200 mesh with two strands in the warp, or 50 × 650 mesh with one strand in the warp. A 3-mil dia wire was used because it was the smallest annealed tantalum wire commercially available.

Composite wire cloths made of two materials—one of tantalum and columbium, the other tantalum and molybdenum—were also produced. Such composites permit selecting one material for surface properties, the other for strength.

Permeability controlled

Permeability or pore size of such cloth can be controlled by

(cont'd on p 163)

NEW ISSUE COMPARES FORMS, PROCESSES

The latest *Materials Selector Issue* provides a unique comparison of materials forms and processes. The issue, published in Mid-October, should by now have reached the desks of all M/DE subscribers.

Like preceding editions, the reference issue contains comprehensive data on all engineering materials, as well as a convenient directory of suppliers. The special *Forms and Shapes* section, however, has been completely revised to provide a thorough, yet concise comparison of virtually every important method of forming metals, plastics and rubber materials. The 35 forming methods covered are compared in terms of their advantages and limitations; materials that can be formed; size, shape and complexity of part produced; tolerances and surface characteristics; cost factors; and typical uses. Presented in data sheet form, the information is the latest available and, in some cases, has not heretofore been published.

it gives you the edge*

CYCOLAC® BRAND
TOUGH, HARD, RIGID POLYMERS FROM BORG-WARNER

This three-way General Electric Household Sharpener required a housing as versatile as the product itself. Because of its contact with knives, scissors and pencils, the housing's surface had to be able to take abuse and constant handling. The answer, of course, was Borg-Warner's CYCOLAC brand polymer . . . tough and light. Of equal importance was the dimensional stability and stain resistance of this remarkable material. Once again this most versatile of plastics has given General Electric a better, more attractive design . . . assured product performance.

And, it can do the same for your product! See for yourself why—
CYCOLAC is better in more ways than any other plastic.
For details write Department L-11.

MARBON CHEMICAL DIVISION **BORG-WARNER**
WASHINGTON WEST VIRGINIA

*CYCOLAC is the registered trademark of Borg-Warner

For more information, turn to Reader Service card, circle No. 410

AFS Plans Center for Training and Research

Plans to build a $600,000 center for research on foundry techniques and training of foundry personnel have been announced by the American Foundrymen's Society.

The site for the proposed AFS Training and Research Center is adjacent to the society's headquarters in Des Plaines, Ill.

The training facilities are intended to educate men entering the metal castings industry, and to keep those already in the field abreast of current developments. Practical training will supplement classroom lectures.

A complete sand laboratory and use of the present foundry of Northwestern University have been offered to the new center.

Newly Formed Plastics Institute Is Setting Its Course

The newly formed Plastics Institute of America is evaluating universities in order to select one with which to affiliate. The institute, which was incorporated this past June after four years of deliberation, has also begun working on two other important tasks: charting the course of several research projects, and gaining in membership.

Many proposals received

The trustees of the PIA have received affiliation proposals from 17 universities and expect many more before they make their choice later this year. The one selected will work with the institute in carrying out its educational objectives, its research programs and its technical information and library services.

According to Tom Zawadski, recently appointed executive secretary of PIA, "The institute will help make the plastics industry more sophisticated. Money will be spent more wisely than in the past."

Research principles

The research group at the institute hopes to begin some projects in the very near future, probably on a contract basis. These activities are now being planned in accordance with the following guiding principles:

1. To conduct research that is too costly for individual companies.
2. To develop basic information that will be useful to all members of the organization.
3. To develop objective standards for the plastics industry in cooperation with standards organizations such as the American Society for Testing and Materials.

The general areas of this research work will be:

- Tabulation of property data.
- Evaluation of test procedures.
- Research on the degradation of plastics.
- Investigation of processing properties.
- Plastics reinforcements.
- Adhesion and cohesion.

New explosive forming facility, *with a capacity for parts up to 8 ft in dia and 6 ft in length, has been constructed at General Dynamics/ Astronautics in San Diego, Calif. The installation was designed to produce missile and satellite parts such as the one shown here which was explosive formed from the sheet metal cone at the left.*

Metal Joining Topics Slated for Symposium

Current developments in metal joining and stress analysis will be presented at a "Metal Joining Symposium" at Pennsylvania

Where Structural Qualities Are Most Important

ZINC DIE CASTING

OFFERS MORE IN

COMPACTNESS
STRENGTH
STABILITY

	ZINC SAE 903 ASTM XXIII (Zamac 3)	THERMOPLASTIC RESINS POLYACETAL (Delrin* Type)	THERMOPLASTIC RESINS ABS (Cycolac† Type)
COMPACTNESS			
EQUIVALENT VOL. TO STRENGTH RATIO	1	2.4 X	2.8 X
STRENGTH			
TENSILE			
1000 psi @ 70°F.	41	10	5.1 - 7.8
212°F	28	4.5 - 5.5	(@ 160°F) 2.9 - 4.6
IMPACT			
ft.-lbs./in. @ −40°F	2	1.2 - 1.8	1 - 2.5
@ 73°F	43	1.4 - 2.3	3 - 9
	Un-notched Charpy	Notched Izod	
COMPRESSION			
1000 psi	60	12 - 18	2.5 - 11
STABILITY			
COEF. OF LINEAR EXPANSION PER °F	.0000152	.000045	.000078 - .00010
WATER ABSORPTION 24 hr. Immersion in %	0	0.12	.2 - .3
MOLD SHRINKAGE in./in.	.004	.020	.005

ABOVE DATA COMPILED 9/61

ST. JOE ZINC 99.99+%

ST. JOSEPH LEAD CO.
250 PARK AVENUE • NEW YORK 17, N.Y.

Plus these zinc die casting extras:

- Zinc is scratch resistant
- Zinc has far superior fatigue strength
- Zinc dies are easier to produce
- Zinc die casting has shortest moulding cycle
- Zinc can be machined by any method without fire hazard
- Zinc is highly resistant to stains
- Zinc can be readily colored and has excellent color retention

*REG. TRADE MARK OF E. I. DU PONT DE NEMOURS & CO. (INC.)
†REG. TRADE MARK OF MARBON CHEMICAL DIVISION, BORG-WARNER

ZN-202

State University, Dec 11-13.

Ultrasonic welding, ductile high temperature brazing alloys, high temperature fatigue strength, and optical methods of stress analysis are among the subjects that will be discussed by men from industry and the university staff. More information may be obtained from the Conference Center, The Pennsylvania State University, University Park, Pa.

Metal Powder Testing, Sampling Revised

A new metal powder standard requires a transverse rupture test for determining green strength.

The new standard, No. 15-61, "Determination of Green Strength of Compacted Metal Powder Specimens," was recently issued by the Metal Powder Producers Assn. Replacing the rattler test specified in standard No. 15-51, the new procedure calls for mounting a transverse rupture test fixture in a universal testing machine or a constant loading beam device. Changes in specimen thickness and weight tolerances are also specified.

A second new standard, No. 1-61, "Method for Sampling Finished Lots of Metal Powders," has been issued to replace No. 1-48. This outlines the procedures for sampling mechanically and manually blended powders and those packaged in containers.

French License Battelle to Study Extrusion

A research license has been gained by Battelle Memorial Institute to investigate further the patented Ugine-Sejournet steel extrusion process, which uses molten glass as the die lubricant.

This is the first time that the French patentee has granted a license for any other organization to conduct independent research on the process. Battelle has studied this technique under the sponsorship of Ugine-Sejournet for the past four years.

Copper Aims at Structural Uses

Four new research projects have been awarded to help develop new or better markets for copper.

They bring to a total of 16 the number of contracts awarded by the Copper Products Development Assn. The CPDA was organized last year to expand the uses of copper through promotion and research. Its research commitments this year now total $400,000.

The new projects aim to:

- Develop a low-bulk high temperature insulation for copper wire, possibly using an electron beam furnace to vapor-deposit refractory oxide coatings.
- Develop ultra high strength copper alloys for structural uses, based on thermal-mechanical strengthening techniques now used for stainless steels.
- Develop more adequate engineering data for the *Cast Bronze Bearing Design Manual* (project cosponsored by the Cast Bronze Bearing Institute).
- Study the effect of surface dislocations on the physical properties of copper.

The projects were awarded, respectively, to Alloyd Corp., Southern Research Institute, Franklin Institute, and Ghent University in Belgium.

Cobalt Alloy Research Recommended

Better utilization of the potential of cobalt-base alloys will require a closer look at some of the materials included in these alloys for many years.

Dr. F. R. Morral, director of Cobalt Information Center activities in this country, recently suggested several avenues of research that might lead to improved properties and greater ease of forming and joining of cobalt alloys. Speaking at a seminar of the Metallurgy Div. of Argonne National Laboratory, he specifically recommended:

1. Investigating alloys containing fewer elements.
2. Further study of precipitation from cobalt solid solutions and dispersion hardening of cobalt solid solutions by means of oxides and intermetallics.
3. Determining the effects of tramp elements on commercial cobalt alloys.

News of Societies

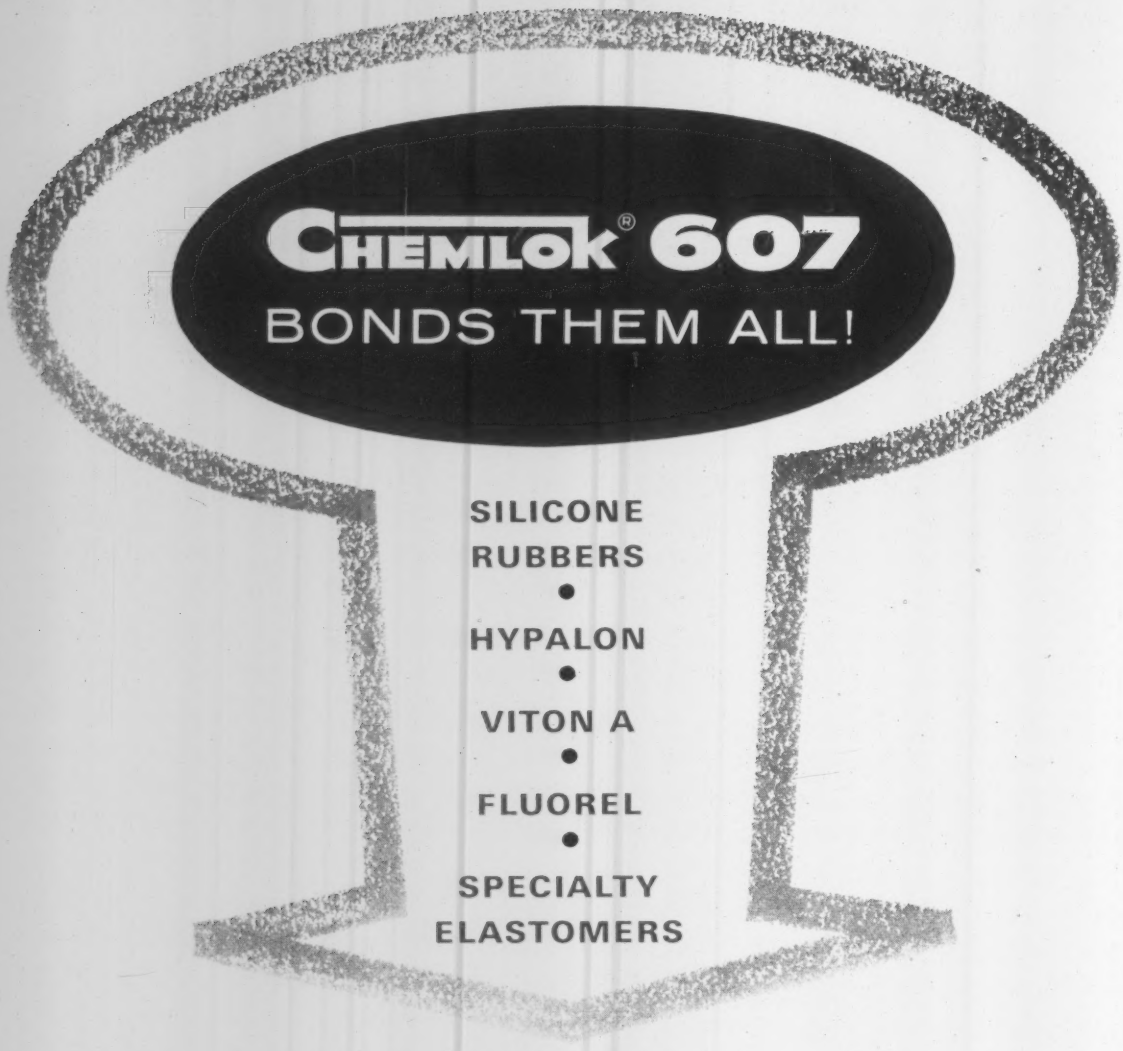
Aerospace Industries Assn. has named John P. Reese to staff its Research and Testing Committee and Manufacturing & Test Equipment Committee.

Metallurgical Society of AIME has announced the establishment of a Fellow membership classification to be awarded to those who have won recognition for outstanding or notable contributions in some phase of metallurgy. The first group will be named before the end of this year.

American Die Casting Institute Inc. has elected the following officers: president—W. E. Brown, Kiowa Corp.; vice-president—W. G. Newton, Jr., Newton-New Haven Co. The Institute has awarded Alfred F. Bauer, Doehler-Jarvis Div., National Lead Co., the Doehler Award for outstanding contributions to the advancement of the die casting art.

Manufacturing Engineering Council has elected the following officers for 1961-2: president—H. Hibler, Designers for Industry, Inc.; vice-president—W. A. Stadtler, IBM Corp.; treasurer—F. I. Ellin, Ohmite Mfg. Co.

Plastics Institute of America, Inc. has elected as president, Tom Zawadzki, Borden Chemical Co.



...and gives you better results at less cost

Chemlok 607 Adhesive offers unmatched advantages for bonding **uncured** specialty elastomers:

Versatility — You can bond a great many compounds of specialty elastomers to metals, glass, plastics, textile fibers and other substrates.

Better Bonding — You get high strength bonds with environmental resistance equal to the stock, even at temperatures as high as 500°F.

Greater Economy — You need only **one** thin coat of Chemlok 607 and you can apply it with standard methods. It dries quickly and is less susceptible to humidity and processing variations. This gives you faster production, more uniform results, less scrap.

It will pay you to investigate Chemlok 607 Adhesive. Write for complete technical details and evaluation samples.

watch Hughson — *for progress through creative research*

hughson

HUGHSON CHEMICAL CO.
A Division of Lord Manufacturing Co.
Erie, Pennsylvania

For more information, turn to Reader Service card, circle No. 379

News of Industry

Coming Meetings

STEEL FOUNDERS' SOCIETY OF AMERICA, 16th annual technical & operating conference. Cleveland. Nov 13-15.

7TH ANNUAL CONFERENCE ON MAGNETISM AND MAGNETIC MATERIALS, American Institute of Electrical Engineers. Phoenix, Ariz. Nov 13-16.

SYMPOSIUM ON CERAMICS AND COMPOSITES, COATINGS AND SOLID BODIES, Society of Aerospace Material and Process Engineers. Dayton, Ohio. Nov 14-15.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, winter meeting. New York City. Nov 26-Dec 1.

28TH EXPOSITION OF CHEMICAL INDUSTRIES. New York City. Nov 27-Dec 1.

19TH ELECTRIC FURNACE CONFERENCE, Metallurgical Society, AIME. Pittsburgh. Dec 6-8.

METAL JOINING SYMPOSIUM, Pennsylvania State University. University Park, Pa. Dec 11-13.

AUTOMOTIVE ENGINEERING CONGRESS & EXPOSITION, Society of Automotive Engineers. Detroit. Jan 8-12.

THERMOPHYSICAL PROPERTIES SYMPOSIUM, Princeton University. Princeton, N. J. Jan 24-26.

18TH ANTEC, Society of Plastics Engineers. Pittsburgh. Jan 30-Feb 2.

17TH REINFORCED PLASTICS DIV. CONFERENCE, Society of the Plastics Industry, Inc. Chicago. Feb 6-8.

GOLDEN GATE METALS CONFERENCE, San Francisco. Feb 15-17.

AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS, annual meeting. New York City. Feb 18-22.

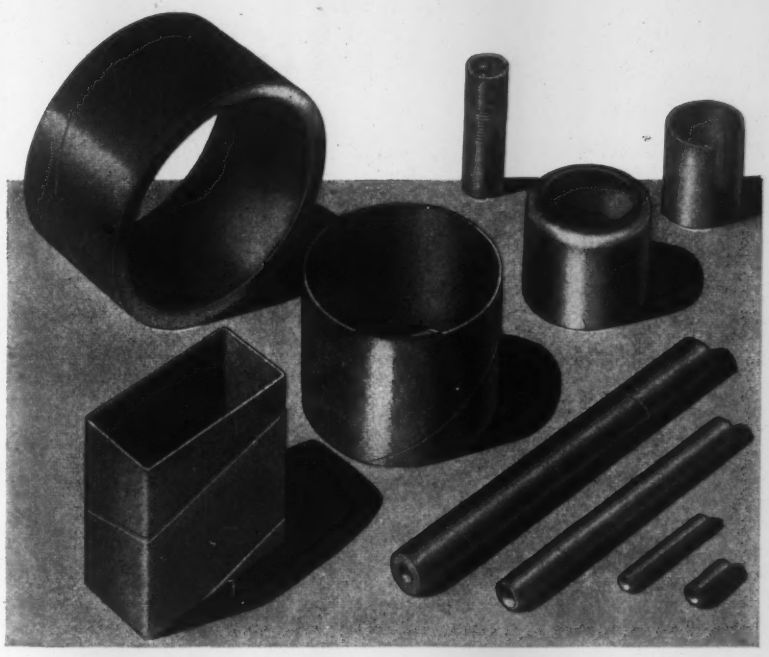
4TH NATIONAL CONFERENCE ON APPLICATION OF ELECTRICAL INSULATION. Washington, D.C. Feb 19-22.

13TH CONFERENCE ON ANALYTICAL CHEMISTRY AND APPLIED SPECTROSCOPY, American Chemical Soc. Pittsburgh. Mar 5-9.

SOCIETY OF VACUUM COATERS, 5th annual technical conference. Cleveland. Mar 6-7.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago. Mar 12-13.

AMERICAN CHEMICAL SOCIETY, 141st national meeting. Washington, D.C. Mar 20-29.



CLEVELITE*

Phenolic Tubing

Hundreds of different, trouble-free applications—ranging from telescope barrels to parts for sensitive electronic equipment—indicate the versatility of spirally-wound **CLEVELITE**—at a substantial saving over most other materials.

CLEVELITE *combines* extraordinary physical characteristics with high insulation resistance. Available in diameters, wall thicknesses and lengths as required, it can be sawed, drilled, punched and machined to meet your needs exactly!

Our plants are also equipped to make a complete line of kraft, fish paper, asbestos, acetate and mylar tubing to your specifications. Fast, dependable deliveries are assured at all times.

Write for our latest, fully illustrated **CLEVELITE** *brochure!*

*Reg. U. S. Pat. Off.

THE
CLEVELAND CONTAINER
COMPANY
6201 BARBERTON AVE., CLEVELAND 2, OHIO
ABRASIVE DIVISION at CLEVELAND, OHIO

PLANTS & SALES OFFICES:
CLEVELAND
CHICAGO
MEMPHIS
DALLAS
LOS ANGELES
PLYMOUTH, WISC.
JAMESBURG, N. J.
GREENSBORO, N.C.

CLEVELAND CONTAINER CANADA, LTD.
TORONTO & PRESCOTT, ONT.

SALES OFFICES:
DETROIT
NEW YORK
WASHINGTON

REPRESENTATIVES:

NEW YORK AREA: WALTER A. MURRAY & CO.
100 HEPBURN ROAD, CLIFTON, N. J.

NEW JERSEY: THE MURRAY SALES CO.
25 W. NORTHFIELD RD., LIVINGSTON, N. J.

NEW ENGLAND: R. S. PETTIGREW & CO.
10 N. MAIN ST., WEST HARTFORD, CONN.

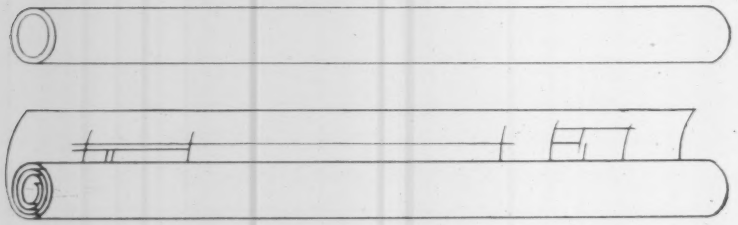
PHILADELPHIA: MIDLANTIC SALES CO.
9 E. ATHENS AVE., ARDMORE, PA.

LOS ANGELES AREA: THE ROBISON CO.
4026 W. 183rd ST., TORRANCE, CALIF.

CANADA: PAISLEY PRODUCTS CO. LTD.
36 UPTON RD., SCARBOROUGH, ONT.

For more information, turn to Reader Service card, circle No. 450

What's so difficult about matching stainless tubing to design ideas?



Nothing, when you share the problem of matching with a B&W tube specialist or a Steel Service Center representative handling B&W stainless tubular products.

With engineering know-how, and a full range of B&W stainless tubing behind him, he can take the million or so possible combinations of stainless grades, tube types, heat treatments, mechanical properties, physical properties, tube sizes and tube costs and help you come up with the one stainless tube that best meets your design requirements.

Why not work with a B&W tube specialist and B&W *Job-Matched* tubing on your next set of stainless tube specifications? You'll find it makes things easier.

The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

TA-1017-S

Seamless and welded tubular products, solid extrusions, rolled rings, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

For more information, turn to Reader Service card circle No. 359

Yeas and Nays for cryogenics

To the Editor:

I want to extend my compliments to you for the fine article on Cryogenics (M/DE, July '61, pp 107-118). Our new technical era requires continuing education in new fields and your presentation is certainly valuable.

HARRY S. BRENNER
President
Almay Research & Testing Corp.
Los Angeles, Calif.

To the Editor:

Why wasn't wood mentioned in your article on cryogenics? It is one of the finest engineering materials for cryogenic applications and is being used in 500,000-gal liquid methane storage units, as insulation on tankers, etc.

RICHARD MARK
President
Action Canoe Co.
Ardsley, N. Y.

Although wood is being used for some cryogenic applications, we did not feel that its engineering applications were sufficiently broad to warrant its inclusion in the article. We would be interested to hear of other cryogenic applications for wood.

Wrong photo credit

To the Editor:

The illustration on p 135 of your special report on "The Future for Ceramics" (M/DE, Sept '61, pp 133-140) was supplied by us but credited to another company.

RUSSELL G. MITCHELL
Sales Manager
McDanel Refractory Porcelain Co.
Beaver Falls, Pa.

Our apologies to McDanel which is always helpful when we need information on ceramic developments.

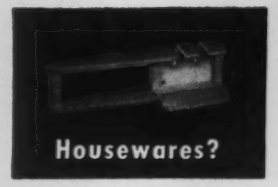
Coating for electrical insulation

To the Editor:

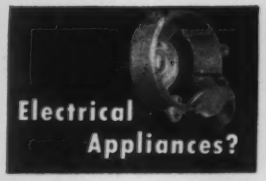
We are having a serious problem in the development of a coating that will provide satisfactory electrical isolation at temperatures up to 1000 F. The coating is for pipe to be used as a conductor-buss of approximately 1500 kva for several hundred feet in the earth.

R. L. CALHOUN
Electrofrac Corp.
Kansas City, Mo.

Our guess is that organic coatings are probably unusable because of the temperature requirement. Silicone coatings for high temperatures are usually



What are your zinc or aluminum



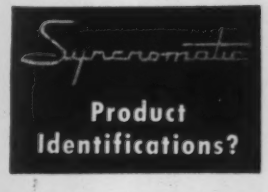
die casting needs...

ADVANCE know-how in Zinc and Aluminum die casting design, engineering and production covers a wide range of component part needs from small camera parts...

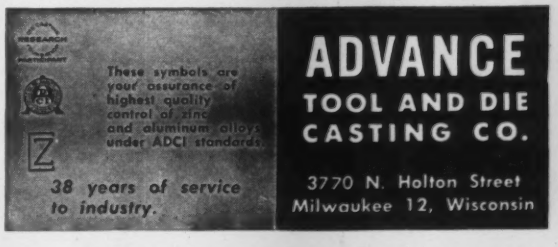
...to engine cylinders

Moreover, ADVANCE often solves a product sales problem by alert die casting engineering and skills which smooth-up product lines and appearance while at the same time improving casting cycles and lowering part costs.

That is why ADVANCE Zinc and Aluminum die cast parts are important components everywhere in home appliances, office equipment, power tools, gas engines, cameras, surveyors' instruments, electric motors and control devices.



Consult ADVANCE about your die cast parts problems . . . and write for folder "YOUR DOORWAY to Certified Zinc and Precision Aluminum Die Castings."


These symbols are your assurance of highest quality control of zinc and aluminum alloys under ADCI standards.
38 years of service to industry.
ADVANCE
TOOL AND DIE CASTING CO.
3770 N. Holton Street
Milwaukee 12, Wisconsin

For more information, turn to Reader Service card, circle No. 369

For over half a century Van Huffel has been the dependable source for quality welded tubing.

ROUND AND SQUARES—⅜" thru 6" in gages from .020 (25 ga.) thru .259 (3 ga.) and all intermediate sizes and gages.

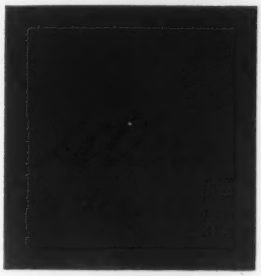
RECTANGLES—⅜" x ⅝" thru 4" x 8" in gages from .020 (25 ga.) thru .259 (3 ga.) and all intermediate sizes and gages.

All Van Huffel Welded Tubing stocks are available through STEEL SERVICE CENTERS in principal cities.

WRITE FOR FREE
60 PAGE HANDBOOK
of engineering data, weights, sizes, tolerances, physical properties, etc. on round, square and rectangular tubing.

VAN HUFFEL
TUBE CORPORATION • WARREN, OHIO

For more information, turn to Reader Service card, circle No. 478



loaded with metallic pigments and will not provide the required electrical insulation. Fired ceramic or porcelain enamels probably will not work because of the lengths of pipe Mr. Calhoun is dealing with. About the only thing we can suggest is a new class of air drying ceramic coatings, said to be good up to 1000 F, which is now being evaluated by the Aeronautical Materials Laboratory in Philadelphia.

Astronaut couch revisited

To the Editor:

I have just finished reading your article on "How Materials Are Used in the Mercury Capsule" (M/DE, Sept '61, p 123) and found it quite interesting. I would like to make a comment, however, on the section that described the astronaut couch. The core of the actual couch is not aluminum honeycomb as you described, but urethane foam. The foam is a pour-in-place system which makes possible the fabrication of custom-tailored couches for each astronaut. The honeycomb is used in the overall couch structure between the actual couch and the pressure bulkhead.

DONALD A. YESKOO
Plastics Advertising
Nopco Chemical Co.
Newark, N. J.

We stand corrected. In cross section the couch consists of 1) an outer reinforced plastics shell; 2) a thick layer of aluminum honeycomb; 3) an intermediate layer of reinforced plastics; 4) a foamed-in-place layer of urethane foam; and 5) another outer shell (next to the astronaut) of reinforced plastic.

Speaking of follow-through . . .

To the Editor:

Regarding your editorial on needing better follow-through on research (M/DE, Sept '61, p 222), it seems to me that we need better follow-through on editorials on research. Please be sure to correct the name of the pioneer investigator of rockets—Goddard, not Stoddard.

Stoddard was the opponent of Dr. Ivy of Krebiozen fame at the University of Illinois. Opinions may vary, but names and facts should be correct in a publication like M/DE.

LADISLAV BOOR
Philadelphia Quartermaster Center
U. S. Army
Philadelphia, Pa.

To the Editor:

Maybe we failed to use Goddard's work faster because we didn't spell his name right.

R. POTTS
Aero Service Corp.
Philadelphia, Pa.

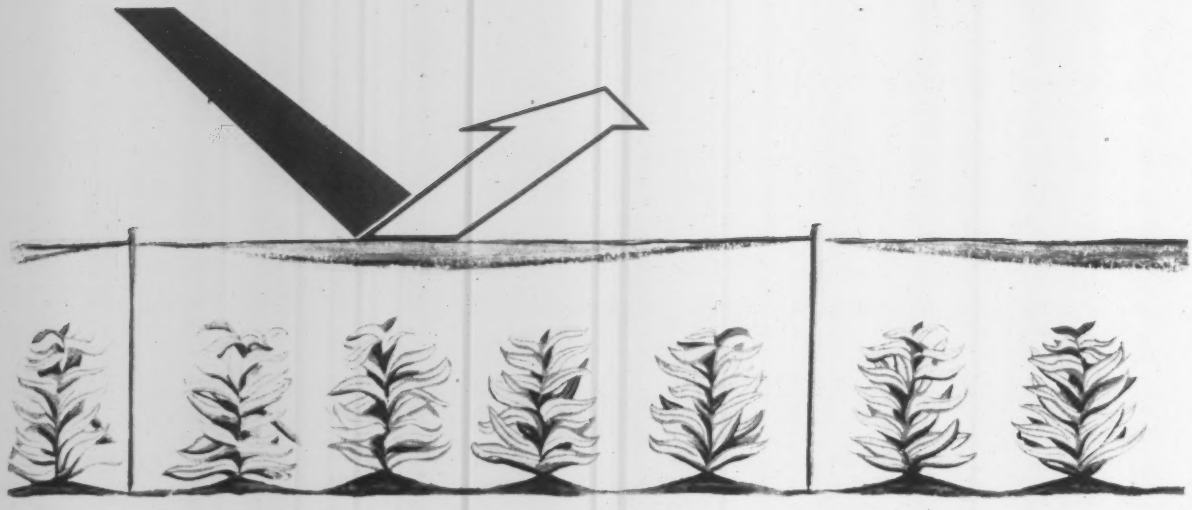
The problem: To remove flux from printed circuit boards, formerly done by hand brushing. This method was slow, expensive and not very efficient.

The solution: A "tailor-made" Branson/Univac system that cleans **completely, continuously,** and **automatically.** The ultrasonic installation consists of two 8 foot tanks, each powered by a 1000 watt generator. It is part of a continuous production line, which automatically supplies flux and solder, ultrasonically cleans and rinses, dries and unloads. This process enables Univac to increase production of printed circuit boards considerably. Ultrasonic cleaning assures complete cleanness at high production speed for critical components.

Whether your products are small or large, simple or complicated, you should investigate the use of ultrasonic equipment for your company. Branson's highly experienced, factory-trained specialists stand ready to assist you anywhere in the U. S. Tell us about your particular problem and Branson's engineering department will try to find the **best** possible solution in the **shortest** possible time.

SINCE 1946 — THE RESPECTED NAME IN ULTRASONICS
BRANSON
INSTRUMENTS, INC.
Ultrasonic Power Division
17 Brown House Road, Stamford, Conn.

For more information, turn to Reader Service card, circle No. 398



Stop Heat Cold With Any Flexible Material—Aluminated

Tobacco men are guessing that Connecticut leaf fields will have a new look next spring. They're betting on shiny, metallic colored shade nets to replace familiar white. Tender tobacco plants need even-temperatured living to stay healthy and spot free. The high reflectivity is expected to even out temperature variations and prolong net life.

Alumination—a new process by Thermo-Chem for impregnating ANY flexible material with aluminum—is behind the speculation on the changing scene. Alumination increases utility and widens useful temperature range by giving up to 20 times more heat (and cold) reflectivity.

Alumination doesn't crack, peel off, discolor. It won't lose its temperature-reflecting ability. And it adds strength and abrasion resistance without excess weight.

Other familiar scenes will change, too. Pipe lines insulated with Aluminated paper. Filter systems lined with Aluminated linen. Hot conveyor belts of Aluminated ordinary duck. The Alumination process adds a thousand new materials for use in hot places.

Take your pick.

Thermo-Chem Corp., 7 Noeland Ave., Penndel, Pa.

THERMO CHEM

For more information, turn to Reader Service card, circle No. 456

You can win up to $500

in the 6th Annual Awards Competition for Best Use of Engineering Materials

16 CASH AWARDS

FIRST AWARD	FIVE AWARDS OF MERIT	TEN CITATIONS
$500 and plaque	$100 each and certificate	$50 each and certificate

Enter any new product or redesigned product, assembly, subassembly or single part that shows sound, imaginative or progressive use of engineering materials.*

**Engineering materials: metals, nonmetallics, finishes and coatings, and materials forms (such as castings, forgings, moldings, etc.)*

Rules of the Competition: A Brief Summary

(For complete details, see October issue, pp 111-114.)

1. Materials producers or suppliers are not eligible.

2. The entry must have been designed, redesigned or put into production during the calendar year of 1961.

3. Provide the following information:

a. A detailed description of the product, including photographs, drawings, before-and-after illustrations, etc.

b. A description of the service and/or fabrication requirements that must be met by the product or material(s).

c. A description of the material(s) previously used (if entry is a redesign).

d. A description of the material(s) selected for the entry.

e. An explanation of *how* and *why* the material(s) selected best met the design and service requirements or (if a redesign) resulted in improved performance and/or lower cost. Back up the selection of the material(s) with evidence—facts, data, charts and tables.

4. Entries or portions thereof will not be returned unless requested. Send copies, not originals, of valuable papers.

5. MATERIALS IN DESIGN ENGINEERING reserves the right to publish articles based on winning and non-winning entries. Payment for non-winning articles published will be at usual rates. Judges reserve right to withhold awards at their discretion.

6. All entries must be postmarked not later than *January 15, 1962.*

For description of last year's award winners see May '61 issue, pp 131-152.

TO SEND YOUR ENTRY:

Use a separate blank for each entry; additional entry blanks available on request. Attach entry blank below, or its equivalent, to your entry and mail to:

Awards Editor, Materials in Design Engineering, 430 Park Ave., N. Y. 22, N. Y.

Name _____ Title _____

Name(s) of person(s), group or organization who would receive award _____

_____

Company _____

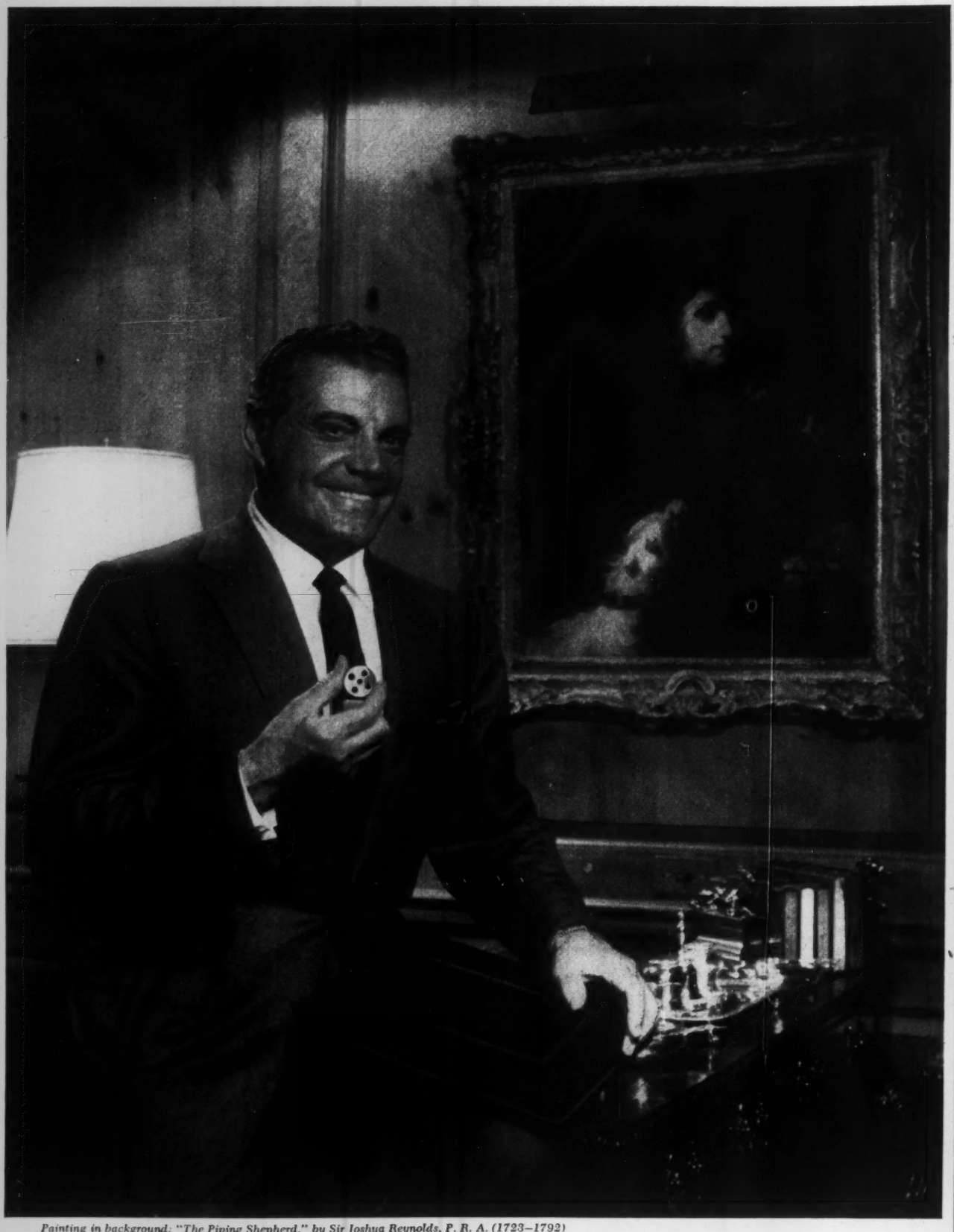
Street address _____ City _____ State _____

Name or brief description of product being entered _____

_____

Was design (or redesign) of entry either completed or placed in production during 1961? _____

Does your employer consent to entry under terms of this competition? _____



Painting in background: "The Piping Shepherd," by Sir Joshua Reynolds, P. R. A. (1723–1792)

New cost savings for users of dielectric materials

. . . a progress report on the MYCALEX METHOD from Jerome Taishoff, President, Mycalex Corporation of America

"I don't have to tell you about the profit squeeze. It's a hard fact-of-life throughout our industry today. That's why we feel the *MYCALEX METHOD*—the unique molding and finishing technique we recently developed—offers so much promise.

Sample quotations point to cost savings up to 84%

"The many months spent in the developing of this new process enable us to turn out better-performing products for less: savings we, in line with our policy, will pass along directly to our customers. And those savings promise to be substantial! Note the typical parts shown in the photograph below, as well as the two mechanical diagrams. As you can see, this new production technique reveals cost reductions of 78% and 84%, respectively, when compared to previous cost quotations." Just as important, the savings are in *addition to* the high reliability SUPRAMICA® ceramoplastics and MYCALEX® glass-bonded micas are noted for.

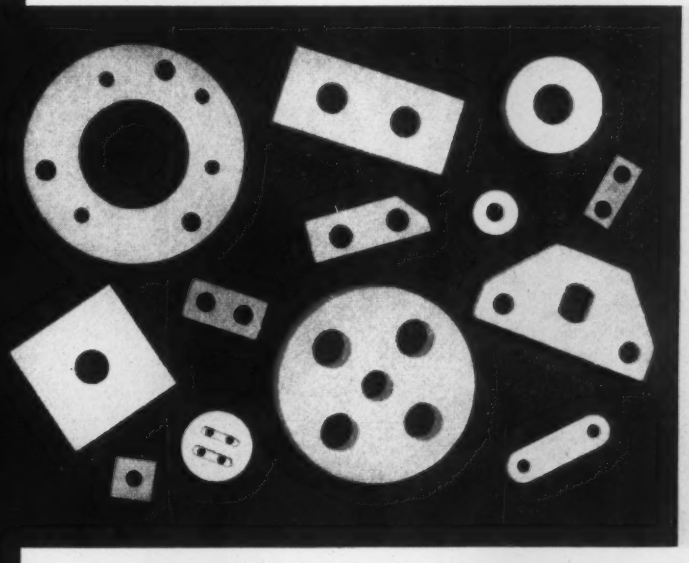
Savings plus quality with the MYCALEX METHOD

Though these intricate parts now cost much less to make—they offer the temperature endurance, total dimensional stability, high dielectric strength and low loss that SUPRAMICA and MYCALEX formulations have been delivering for years.

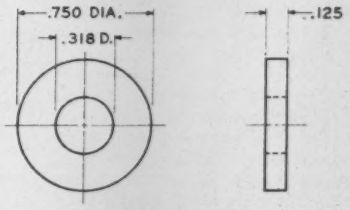
Choose from any of these famous materials

SUPRAMICA 620 "BB", 560 and 555 ceramoplastics and MYCALEX 410 glass-bonded mica. *Maximum Temperature Endurance* (unstressed): 1200, 930, 650 and 650°F; *Loss Factor* (10^6 cycles/sec.): 0.020, 0.010, 0.013, 0.010; *Compressive Strength* (psi): 30,000, 25,000, 40,000 and 40,000, respectively.

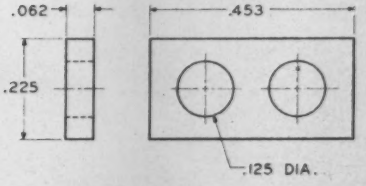
So for electronic insulation materials with the high-performance properties you must have—at a profit-protecting price — look into the new *MYCALEX METHOD*. Send your blueprints and drawings for specific quotations and information.



78% LOWER IN PRICE



84% LOWER IN PRICE



SYNTHAMICA® SYNTHETIC MICA · SINCE 1919 MYCALEX® THE INVISIBLES · SUPRAMICA® CERAMOPLASTIC

MYCALEX
CORPORATION OF AMERICA

General Offices and Plant: 122 Clifton Boulevard, Clifton, N. J.
Executive Offices: 30 Rockefeller Plaza, New York 20, N. Y.

World's largest manufacturer of ceramoplastics, glass-bonded mica and synthetic mica products

For more information, turn to Reader Service card, circle No. 466

LUST

THE PLASTIC WITH THE RIGHT LEVEL OF

Starting just pennies above high impact styrene, new Lustran provides a balanced combination of light weight, superior toughness and rigidity, and excellent stability and colorability.

Check the range of the key properties, tensile and impact strengths, of typical Lustran formulations in the chart at right. One formulation will give you four times the impact resistance of rubber-modified styrene and ten times that of general purpose styrene. At zero degrees fahrenheit, a ⅛-inch thick 24-inch square sheet withstands the shock of a 6-pound ball dropped 48 inches. Lustran also gives excellent gloss, abrasion and chemical resistance, and comes in unlimited colors.

Lustran—a unique molecular arrangement of styrene, acrylonitrile and butadiene—has been successfully injection molded into parts weighing as much as 5 pounds and vacuum formed into deep-drawn parts weighing up to 11 pounds. If you are working on a design where the performance-cost balance is critical, write to us describing your requirements—or send for Lustran Progress Report and complete test data to Monsanto Chemical Company, Plastics Division, Department 834, Springfield 2, Massachusetts.

®LUSTRAN: T. M. Monsanto Chemical Company

Monsanto

MONSANTO designer in **PLASTICS**

LUSTRAN

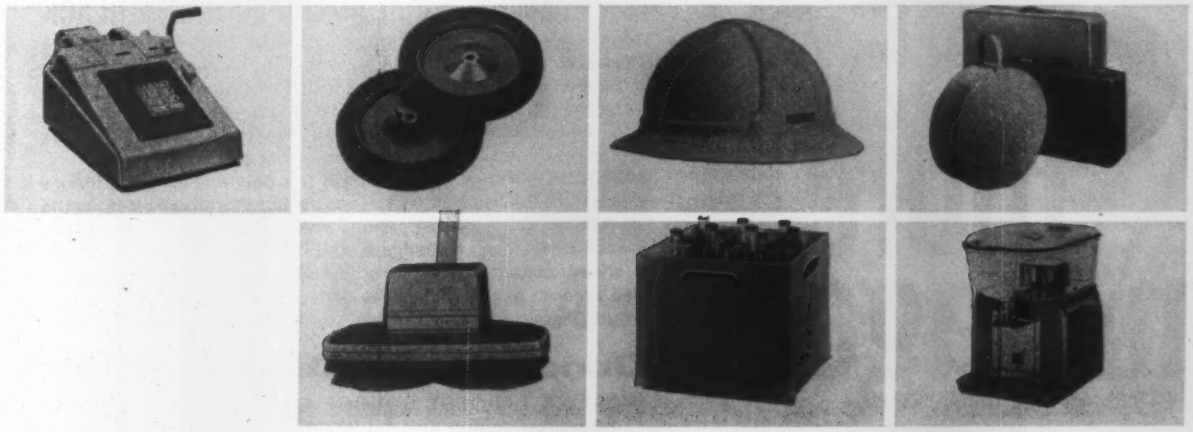
EFFECTIVE STRENGTH AT THE RIGHT COST

CHECK THE RANGE OF KEY PROPERTIES OF TYPICAL LUSTRAN FORMULATIONS:

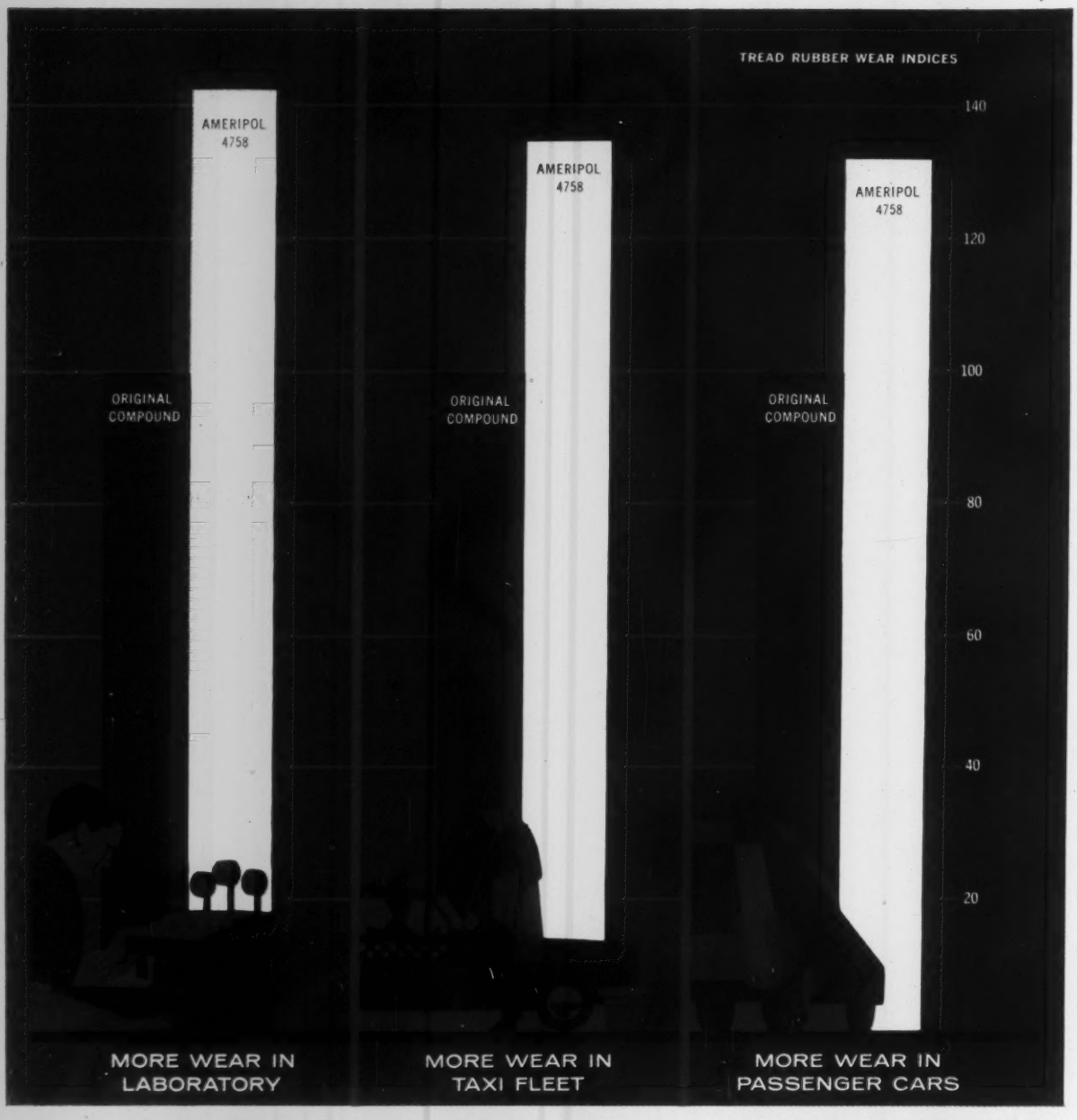
PROPERTIES	TEST CONDITIONS	UNITS	MOLDING FORMULATIONS 210	MOLDING FORMULATIONS 710	EXTRUSION* FORMULATIONS 261	EXTRUSION* FORMULATIONS 761	ASTM
Tensile							
Stress at Yield	73° F.	psi	9,000	6,200	6,800	5,100	D638-58T
Stress at Failure	73° F.	psi	6,800	5,200	6,200	4,500	D638-58T
Elongation at Yield	73° F.	%	3.3	3.2	2.2	2.5	D638-58T
Elongation at Failure	73° F.	%	45**	70**	25	40	D638-58T
Modulus in Tension	73° F.	psi	420,000	300,000	380,000	290,000	D638-58T
Impact Strength							
Izod ½" x ½" Bar Mld. (.010" Notch Radius)	73° F.	ft. lbs./in. of notch	1.1	4.3	0.9†	3.6	D256-56
	0° F.	ft. lbs./in. of notch	0.8	2.0	0.6†	1.5	D256-56
	−40° F.	ft. lbs./in. of notch	0.6	1.4	0.6†	1.1	D256-56
Izod ⅛" x ½" Bar Mld. (.010" Notch Radius)	73° F.	ft. lbs./in. of notch	1.3–4.0	6.0–8.5			D256-56
	0° F.	ft. lbs./in. of notch	0.7–1.2	2.0–2.6			D256-56
	−40° F.	ft. lbs./in. of notch	0.6–0.8	1.1–1.8			D256-56

*Data on Extruded Sheet **Monsanto Test †½" x 0.115" Bar-Sheet

Lustran's combination of light weight, superior toughness and rigidity, excellent thermal stability, colorability, gloss, and abrasion and chemical resistance provides new opportunities for creative industrial design.



For more information, turn to Reader Service card, circle No. 477



"35% more mileage"

...with tread rubber made of AMERIPOL MICRO-BLACK

The goal was clear-cut—to dramatically improve the wear quality of the first line and premium tread rubber made by McCreary Tire & Rubber Company, Indiana, Pennsylvania. The recommendation made by the Goodrich-Gulf sales engineer—"Try the new AMERIPOL Micro-Black 4758." The results—an average improvement of 35% in tire tread wear . . . proven in actual fleet use. In addition, tires are quieter, stronger, and have better shock absorbing properties.

AMERIPOL MICRO-DISPERSION. The secret of the outstanding performance of AMERIPOL black masterbatch is jet-stream mixing of carbon black in the latex. This produces a superior dispersion, which greatly improves tensile strength and wear resistance. Investigate AMERIPOL Micro-Black for tires, tread rubber, shoes, coated fabrics or other black rubber products. You'll realize improved product quality, as well as materials and production savings. Call Goodrich-Gulf Chemicals, Inc., 1717 East Ninth Street, Cleveland 14, Ohio.

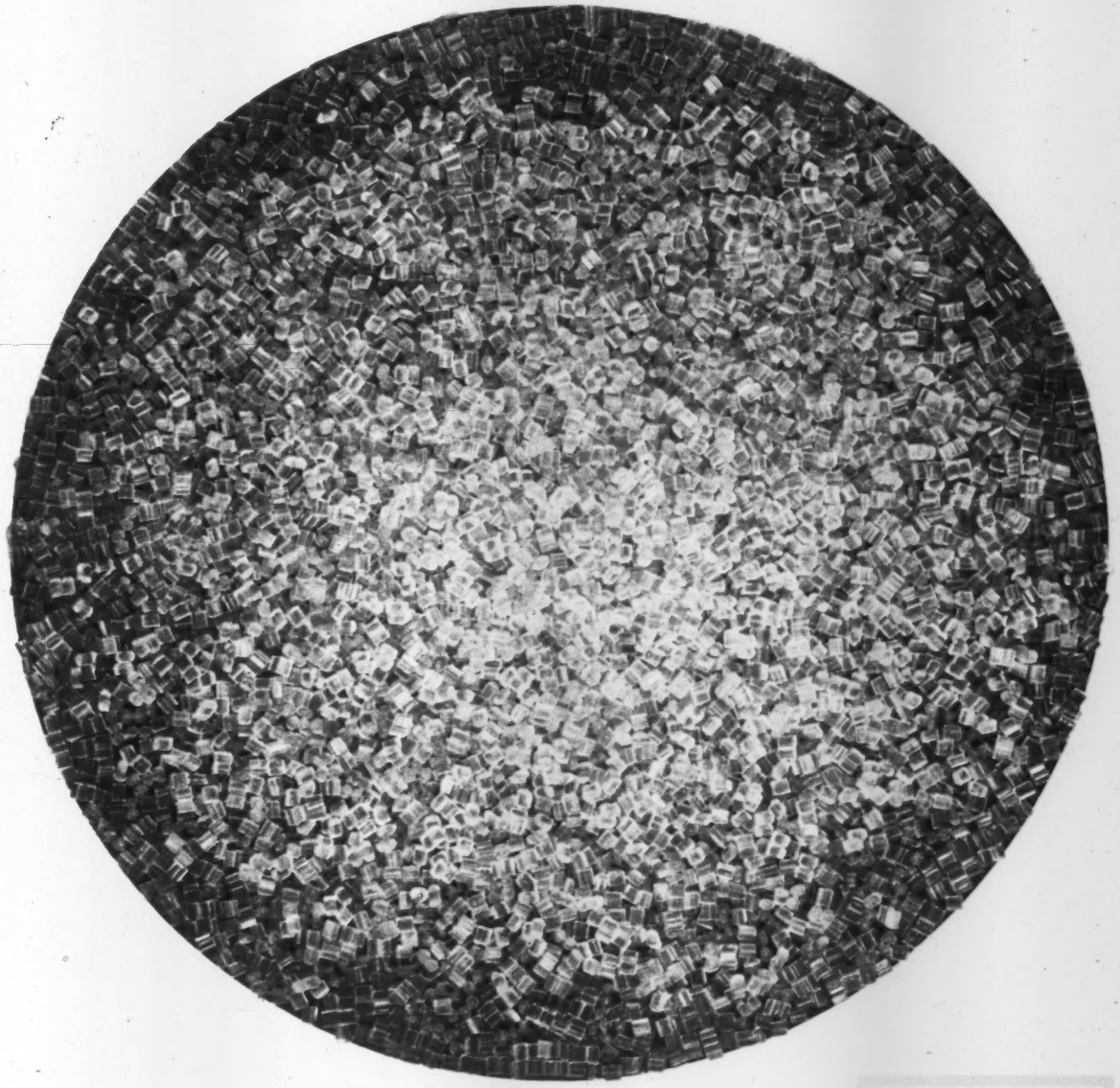
Goodrich-Gulf Chemicals, Inc.

WORLD'S LARGEST SOURCE OF SYNTHETIC RUBBER

For more information, circle No. 481

For more information, circle No. 459

ANNOUNCING! Plaskon® POLYPROPYLENE



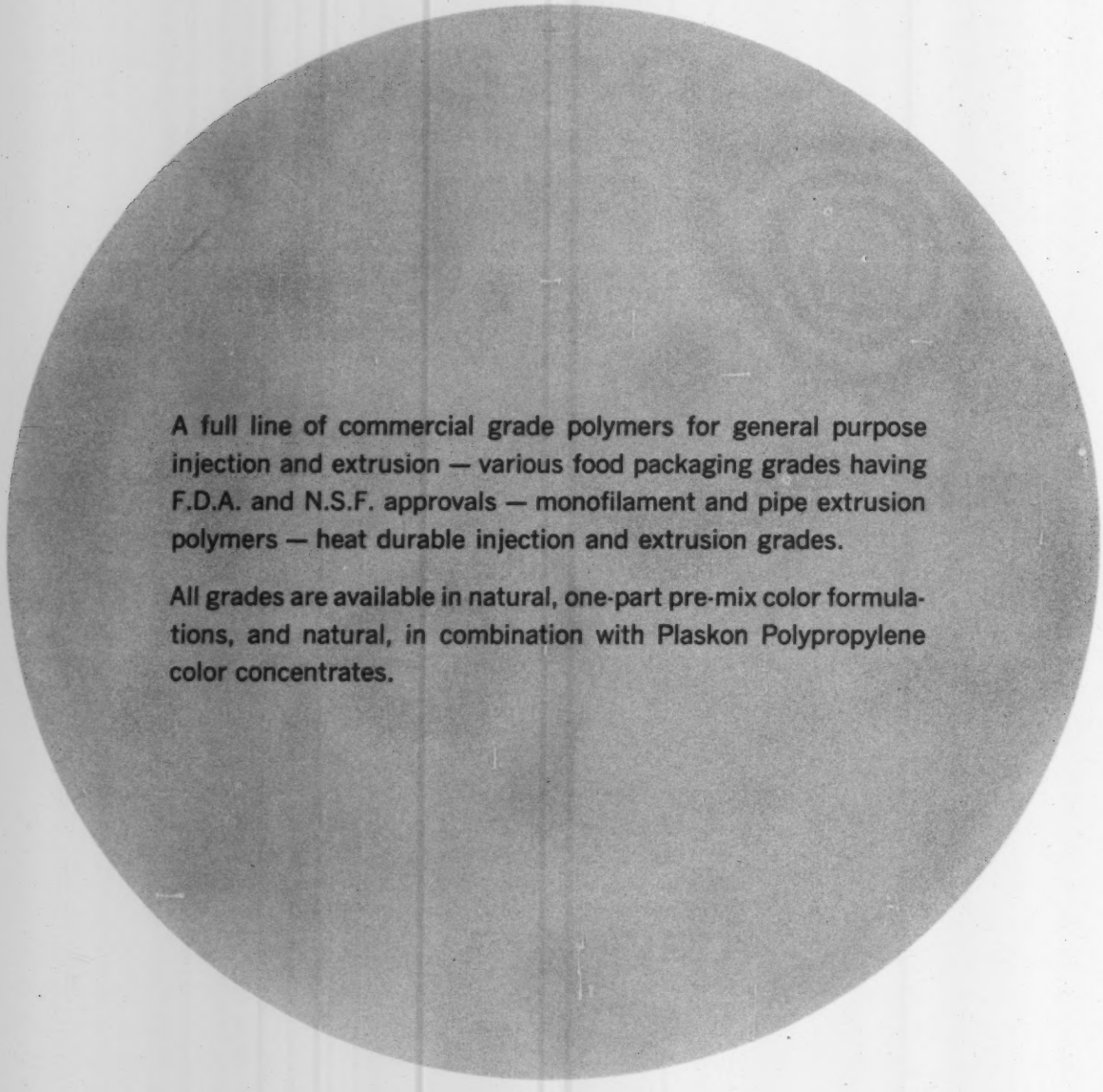
ALLIED CHEMICAL IS PROUD TO ANNOUNCE POLYPROPYLENE: THE NEWEST ADDITION TO ITS ESTABLISHED LINE OF PLASKON PLASTICS AND RESINS.

Allied Chemical

PLASTICS DIVISION

40 Rector Street, New York 6, N. Y.

Plaskon POLYPROPYLENES... OFFER AN EXCELLENT COMBINATION OF PROPERTIES OVER A WIDE TEMPERATURE RANGE



A full line of commercial grade polymers for general purpose injection and extrusion — various food packaging grades having F.D.A. and N.S.F. approvals — monofilament and pipe extrusion polymers — heat durable injection and extrusion grades.

All grades are available in natural, one-part pre-mix color formulations, and natural, in combination with Plaskon Polypropylene color concentrates.

Plaskon Polypropylene offers a valuable combination of properties. Easy to mold, this plastic is so light, it floats on water, so super resilient it can be flexed for years without fatigue or breaking. In addition, Plaskon Polypropylene is more resistant to high temperatures than most other commonly used thermoplastics. Other important properties include: low permeability to water, vapor, and solvents; excellent resistance to creep and environmental stress cracking; rigidity; high impact strength.

PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical
BASIC TO AMERICA'S PROGRESS

Plaskon

POLYPROPYLENE...BACKED BY EXPERIENCED TECHNICAL TEAMS

It will pay you to specify Plaskon Polypropylene.

From modern research laboratories for product testing and evaluation, to mold design, and through the finished product, Plastic Division's Technical Service Team is on the job to help designers and molders obtain the right plastic for the right job.

Plaskon technicians have the know-how and facilities to assure top performance of Plaskon Polypropylene for your product.

PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

BASIC TO AMERICA'S PROGRESS

Plaskon POLYPROPYLENE...BACKED BY KNOWLEDGE GAINED THROUGH FIVE YEARS OF RESEARCH AND DEVELOPMENT

PROPERTIES OF PLASKON POLYPROPYLENE

Properties & Conditions	ASTM Test Method	Units	Value
Density	D-792-60T	GM/ML	0.91
Melt Flow Rate, 230°C., 2160 GM. Load	D-1238-57T (Modified)	GM/10 Min.	0.3-7.5[1]
Mechanical (At 73°F.)			
Tensile Yield Strength At 2 IN/MIN	D-638-60T	PSI	4900
Ultimate Tensile Elongation At 2 IN/MIN	D-638-60T	%	250
Stiffness—Flexural	D-747-58T	PSI	150,000
Impact Strength, Izod	D-256-56	FT/LB/In Notch	0.8-1.2
Hardness—Rockwell	D-785-60T	R Scale	92
Thermal			
Melting Point		°F.	346
Deflection Temperature Under Load			
66 PSI	D-648-56	°F.	245
264 PSI	D-648-56	°F.	145
Deformation Under Load 2000 PSI, 122°F., 24 Hrs.	D-621-59	%	3.0
Miscellaneous			
Environmental Stress Cracking	Bell. Labs. Test		None

(1) PLASKON Polypropylenes are available in a range of melt flow rates.

Plaskon Polypropylene is backed by Allied Chemical — one of the world's largest producers of chemicals and plastics. Quality is assured through rigid control procedures . . . satisfaction in molding through Allied's expert technical service team. Listed above are just a few of Plaskon Polypropylene's specifications. For complete performance data and technical information write:

DISTRICT SALES OFFICES

N. Y. METROPOLITAN DISTRICT	261 Madison Ave. New York 16, N. Y.	HAnover 2-7300	BOSTON DISTRICT	150 Causeway St. Boston 14, Mass.	CApital 7-0490
CHICAGO DISTRICT	Merchandise Mart Room 430 Chicago 54, Ill.	MIchigan 2-1800	PHILADELPHIA DISTRICT	12 South 12th St. Philadelphia 7, Pa.	WAlnut 2-1234
LOS ANGELES DISTRICT	2801 Lynwood Road Lynwood, Calif.	NEvada 6-2306	CLEVELAND DISTRICT	3121 Euclid Ave. Cleveland 32, Ohio	HEnderson 2-2020

PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

BASIC TO AMERICA'S PROGRESS

Bridgeport's new name for 5 billion feet— and 15 years' experience—in coated aluminum

FLEX-COLOR® is the new "shorthand" for coated aluminum sheet that does its job so well that billions of feet have been converted into product performance and satisfaction. This is the coated sheet pioneered in 1946 by Bridgeport's Hunter Douglas Division, and improved every year since by the comparative testing of every new coating for every type of performance.

FLEX-COLOR combines the dependability of performance-tested coatings with aluminum alloys specially rolled in Bridgeport mills to the highest standards of quality.

FLEX-COLOR encompasses a remarkably diverse experience in coatings systems that lets Bridgeport help you select the alloy and coating that suits your production requirements and product performance.

FLEX-COLOR is the all-the-way service that starts with product planning. Call your nearest Bridgeport Sales Office.

BRIDGEPORT FLEX-COLOR ALUMINUM SHEET

- all colors, including metallics
- all finishes from enamel to matte
- single or double-coated
- colors on one or both sides
- solid colors and 2-color patterns
- long-length rolls to 20,000 ft.

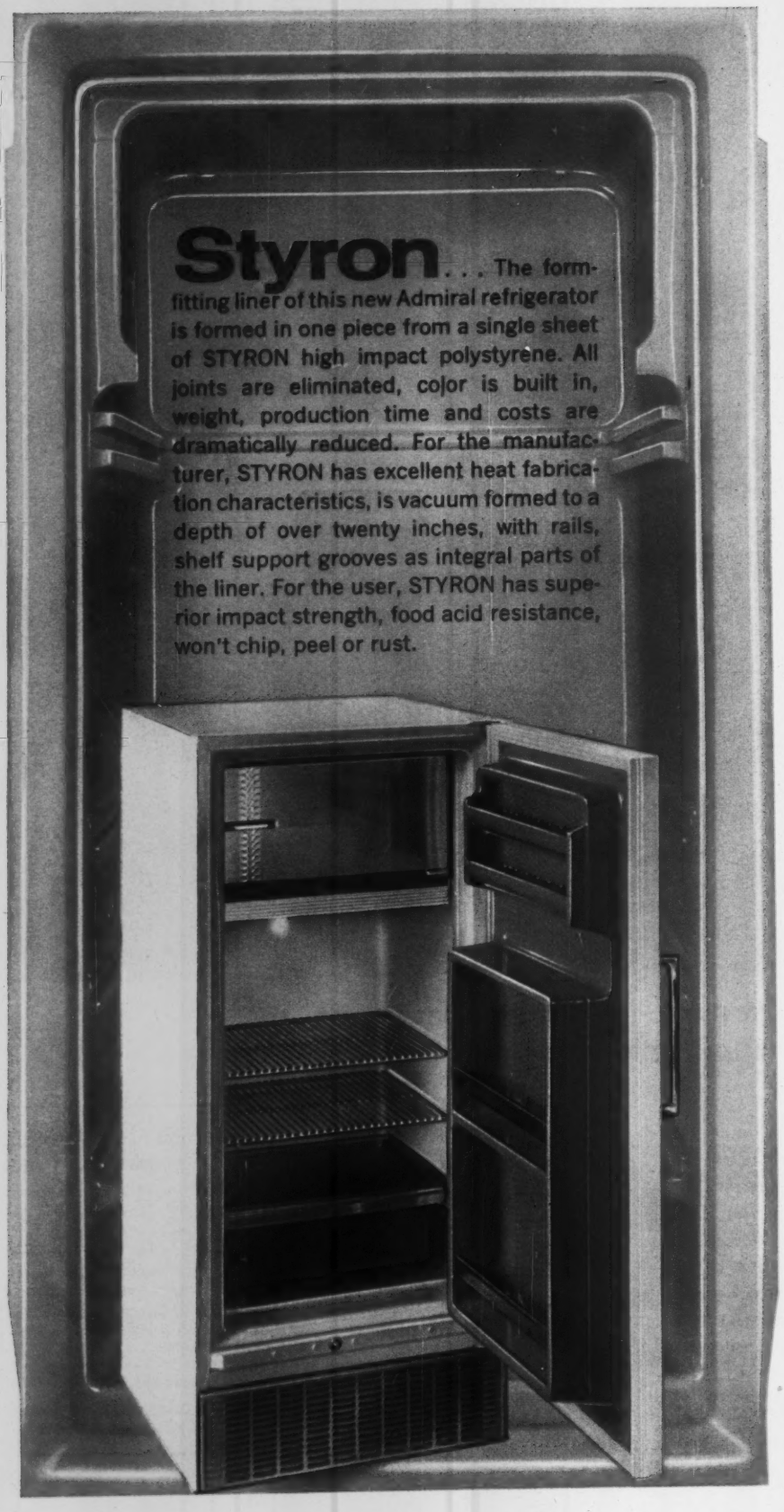
. . . all coated on aluminum specially rolled by Bridgeport to exacting gage and width specifications.
Write for samples of specific finishes in Bridgeport FLEX-COLOR aluminum.

Bridgeport Brass Company, Bridgeport 2, Connecticut

BRIDGEPORT FLEX-COLOR **ALUMINUM**

For more information, circle No. 459

For more information, turn to Reader Service card, circle No. 472


Styron . . . The form-fitting liner of this new Admiral refrigerator is formed in one piece from a single sheet of STYRON high impact polystyrene. All joints are eliminated, color is built in, weight, production time and costs are dramatically reduced. For the manufacturer, STYRON has excellent heat fabrication characteristics, is vacuum formed to a depth of over twenty inches, with rails, shelf support grooves as integral parts of the liner. For the user, STYRON has superior impact strength, food acid resistance, won't chip, peel or rust.

Styron ... high impact Dow polystyrene

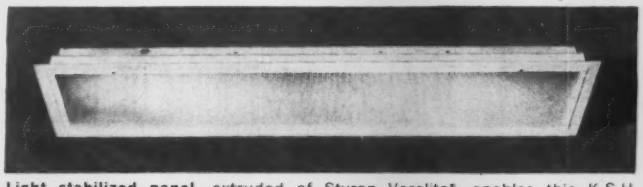
streamlines production in deep-draw, vacuum-forming operation for Admiral

The Styron® high impact polystyrene liner in Admiral Sales Corporation's new nine-cubic-foot apartment-size refrigerator cuts production time by 90% and up-grades quality and product appearance at the same time. This new concept in thermal forming offers designers and fabricators unlimited opportunities for deep-draw, one-piece components.

Using a new rotary vacuum-forming machine, and fifteen pounds of high-impact Styron 475B, Admiral deep-forms a one-piece refrigerator liner 46½" high x 23¾" wide x 20$^{12}/_{32}$" deep *in two minutes!* Contrast the half-hour total production time and the reduction in float quantities required in this operation with the five hours' total production time and twenty-two pounds of material required to fabricate the previously used liner.

The finished design: a smooth, food acid resistant liner with built-in color that won't crack, chip, or rust . . . with no joints . . . and with more efficient insulating qualities. Formed into the liner are the crisper rail, two shelf supports, grooves, a two-position freezer drawer slide rail, and four bosses for mounting the evaporator.

The unusual size of Admiral's one-piece vacuum-forming operation opens the door to deep-drawn designs of even larger and more complex shapes. May we add our experience to yours to help solve a design problem? Drop us a line in Midland, Attention: Plastics Sales Department 1721CD11.



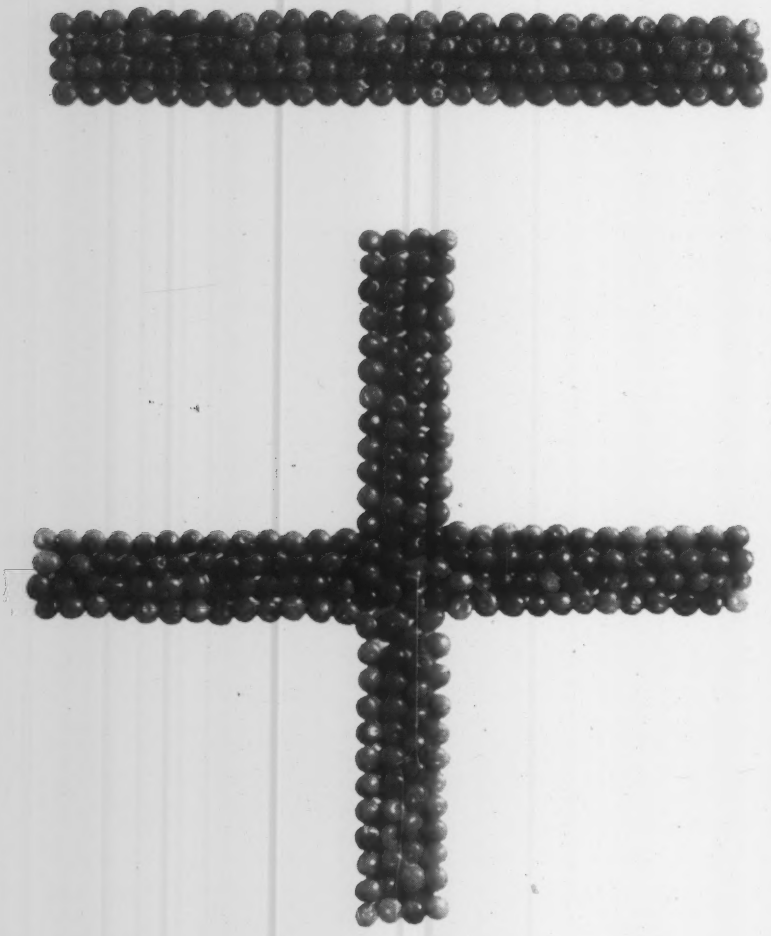
Light stabilized panel, extruded of Styron Verelite®, enables this K-S-H lighting fixture to provide a low brightness controlled light.

Transistor radio-phono combination by Bell Products is enclosed in case of Styron® for good impact strength and brilliant color styling.

Wastebasket by Rubbermaid uses flexible, chip-resistant, easy-to-clean Dow medium density polyethylene. Letter tray of Styron.

THE DOW CHEMICAL COMPANY Dow **Midland, Michigan**

For more information, turn to Reader Service card, circle No. 483



THAT EXTRA TOUCH OF GRACE: Financial Counseling

The difference between a profit and a loss often hinges on a single financial decision. Competition in plastics products is so fierce these days that how you handle your inventory control, working capital or mold costs can change the color of the ink on your P&L statement. Your Grace representative offers financial counseling as one of the ten major services available under the Grace Service Plan. Ask him how we can put that extra touch of Grace to work for you.

W. R. GRACE & CO. POLYMER CHEMICALS DIVISION, CLIFTON, N. J.

GREX® POLYETHYLENES · GRACE POLYSTYRENES · MOPLEN* POLYPROPYLENES · *MONTECATINI TRADEMARK

GRACE PLASTICS

For more information, turn to Reader Service card, circle No. 360

Reader Service

Use these postage-free cards to request:

- **SUPPLIERS' FREE LITERATURE.** Turn page for current list, pp 43-47.
- **INFORMATION ON ADVERTISED PRODUCTS.** Key numbers appear on or next to most advertisements in this issue.
- **MORE INFORMATION ON NEW PRODUCTS.** A key number is given at the end of most articles in the What's New in Materials section.
- **REPRINTS OF M/DE MANUALS.** These are available for a small charge; see reverse side of this card.
- **SUBSCRIPTION TO M/DE.** Just check one of the blocks provided at bottom of reply card.

Simply circle the appropriate key numbers on the card and drop it in the mail. Be sure to **print** your name, title and business address.

New materials in this issue:

	Page	Circle Key No.
METALS		
Stainless steel for cold heading	9	600
Refractory metal cloth has fine mesh	15	611
High luster sheet	174	619
Tubular steel	178	623
Beryllium copper	192	633
PLASTICS		
Elastomer resists heat, ozone, weathering	10	601
New polyethylenes	166	612 to 616
Flexible phenolics	180	624
Hard-soft rubber seals	184	627
Surfacing material	186	630
OTHER NONMETALLICS		
Mica paper tubing useful up to 1500 F	178	622
Cutting-grade carbide	184	628
Durable coated fabrics	188	631
Metal-faced insulation	198	638
FINISHES, COATINGS		
Transparent coatings for aluminum foil	176	621
Anti-static fluid for plastic surfaces	186	629
Chromate coating	196	636
JOINING & FASTENING		
Refractory cements good up to 5300 F	12	602
Tin-lead solder	182	625
Rubber-base adhesive	200	639

FIRST CLASS
PERMIT NO. 1538
NEW YORK, N. Y.

BUSINESS REPLY CARD
No postage stamp necessary if mailed in the U. S.

POSTAGE WILL BE PAID BY —

MANAGER, READER SERVICE DEPARTMENT 1161

MATERIALS IN DESIGN ENGINEERING

430 PARK AVENUE

NEW YORK 22, N. Y.

5648PP

THIS CARD NOT GOOD AFTER JANUARY 1 11/61

Name Title

Firm

Street City

Zone State Prod. Mfd.

Students and foreign subscribers (other than Canadian), please request literature directly from manufacturers.

1	26	51	76	101	126	151	176	201	226	251	276	301	326	351	376	401	426	451	476	501	526	551	576	601	626	651	676
2	27	52	77	102	127	152	177	202	227	252	277	302	327	352	377	402	427	452	477	502	527	552	577	602	627	652	677
3	28	53	78	103	128	153	178	203	228	253	278	303	328	353	378	403	428	453	478	503	528	553	578	603	628	653	678
4	29	54	79	104	129	154	179	204	229	254	279	304	329	354	379	404	429	454	479	504	529	554	579	604	629	654	679
5	30	55	80	105	130	155	180	205	230	255	280	305	330	355	380	405	430	455	480	505	530	555	580	605	630	655	680
6	31	56	81	106	131	156	181	206	231	256	281	306	331	356	381	406	431	456	481	506	531	556	581	606	631	656	681
7	32	57	82	107	132	157	182	207	232	257	282	307	332	357	382	407	432	457	482	507	532	557	582	607	632	657	682
8	33	58	83	108	133	158	183	208	233	258	283	308	333	358	383	408	433	458	483	508	533	558	583	608	633	658	683
9	34	59	84	109	134	159	184	209	234	259	284	309	334	359	384	409	434	459	484	509	534	559	584	609	634	659	684
10	35	60	85	110	135	160	185	210	235	260	285	310	335	360	385	410	435	460	485	510	535	560	585	610	635	660	685
11	36	61	86	111	136	161	186	211	236	261	286	311	336	361	386	411	436	461	486	511	536	561	586	611	636	661	686
12	37	62	87	112	137	162	187	212	237	262	287	312	337	362	387	412	437	462	487	512	537	562	587	612	637	662	687
13	38	63	88	113	138	163	188	213	238	263	288	313	338	363	388	413	438	463	488	513	538	563	588	613	638	663	688
14	39	64	89	114	139	164	189	214	239	264	289	314	339	364	389	414	439	464	489	514	539	564	589	614	639	664	689
15	40	65	90	115	140	165	190	215	240	265	290	315	340	365	390	415	440	465	490	515	540	565	590	615	640	665	690
16	41	66	91	116	141	166	191	216	241	266	291	316	341	366	391	416	441	466	491	516	541	566	591	616	641	666	691
17	42	67	92	117	142	167	192	217	242	267	292	317	342	367	392	417	442	467	492	517	542	567	592	617	642	667	692
18	43	68	93	118	143	168	193	218	243	268	293	318	343	368	393	418	443	468	493	518	543	568	593	618	643	668	693
19	44	69	94	119	144	169	194	219	244	269	294	319	344	369	394	419	444	469	494	519	544	569	594	619	644	669	694
20	45	70	95	120	145	170	195	220	245	270	295	320	345	370	395	420	445	470	495	520	545	570	595	620	645	670	695
21	46	71	96	121	146	171	196	221	246	271	296	321	346	371	396	421	446	471	496	521	546	571	596	621	646	671	696
22	47	72	97	122	147	172	197	222	247	272	297	322	347	372	397	422	447	472	497	522	547	572	597	622	647	672	697
23	48	73	98	123	148	173	198	223	248	273	298	323	348	373	398	423	448	473	498	523	548	573	598	623	648	673	698
24	49	74	99	124	149	174	199	224	249	274	299	324	349	374	399	424	449	474	499	524	549	574	599	624	649	674	699
25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700

I would like to subscribe to Materials in Design Engineering for ☐ 1 year $3.00 ☐ 2 years $5.00

Subscribe now

to see these forthcoming articles:

THERMOELECTRIC MATERIALS
What makes a good one and where we stand today

COLUMBIUM
Present and future alloys, fabrication, uses

ADHESIVE BONDING
State of the art as revealed by a recent symposium

These are but a few of the outstanding articles you may miss if you do not receive your own copy of M/DE each month. If you need to know the latest about engineering materials, forms and finishes, why not make sure you see **every copy** of the one magazine edited solely for this purpose. Cost: only $3.00 per year (in U. S.); $5.00 for two years. To start your issues coming, simply check one of the two boxes at the bottom of the postage-free card.

THIS CARD NOT GOOD AFTER JANUARY 1 11/61

Name _____ Title _____

Firm _____

Street _____ City _____

Zone _____ State _____ Prod. Mfd. _____

Students and foreign subscribers (other than Canadian), please request literature directly from manufacturers.

1	26	51	76	101	126	151	176	201	226	251	276	301	326	351	376	401	426	451	476	501	526	551	576	601	626	651	676
2	27	52	77	102	127	152	177	202	227	252	277	302	327	352	377	402	427	452	477	502	527	552	577	602	627	652	677
3	28	53	78	103	128	153	178	203	228	253	278	303	328	353	378	403	428	453	478	503	528	553	578	603	628	653	678
4	29	54	79	104	129	154	179	204	229	254	279	304	329	354	379	404	429	454	479	504	529	554	579	604	629	654	679
5	30	55	80	105	130	155	180	205	230	255	280	305	330	355	380	405	430	455	480	505	530	555	580	605	630	655	680
6	31	56	81	106	131	156	181	206	231	256	281	306	331	356	381	406	431	456	481	506	531	556	581	606	631	656	681
7	32	57	82	107	132	157	182	207	232	257	282	307	332	357	382	407	432	457	482	507	532	557	582	607	632	657	682
8	33	58	83	108	133	158	183	208	233	258	283	308	333	358	383	408	433	458	483	508	533	558	583	608	633	658	683
9	34	59	84	109	134	159	184	209	234	259	284	309	334	359	384	409	434	459	484	509	534	559	584	609	634	659	684
10	35	60	85	110	135	160	185	210	235	260	285	310	335	360	385	410	435	460	485	510	535	560	585	610	635	660	685
11	36	61	86	111	136	161	186	211	236	261	286	311	336	361	386	411	436	461	486	511	536	561	586	611	636	661	686
12	37	62	87	112	137	162	187	212	237	262	287	312	337	362	387	412	437	462	487	512	537	562	587	612	637	662	687
13	38	63	88	113	138	163	188	213	238	263	288	313	338	363	388	413	438	463	488	513	538	563	588	613	638	663	688
14	39	64	89	114	139	164	189	214	239	264	289	314	339	364	389	414	439	464	489	514	539	564	589	614	639	664	689
15	40	65	90	115	140	165	190	215	240	265	290	315	340	365	390	415	440	465	490	515	540	565	590	615	640	665	690
16	41	66	91	116	141	166	191	216	241	266	291	316	341	366	391	416	441	466	491	516	541	566	591	616	641	666	691
17	42	67	92	117	142	167	192	217	242	267	292	317	342	367	392	417	442	467	492	517	542	567	592	617	642	667	692
18	43	68	93	118	143	168	193	218	243	268	293	318	343	368	393	418	443	468	493	518	543	568	593	618	643	668	693
19	44	69	94	119	144	169	194	219	244	269	294	319	344	369	394	419	444	469	494	519	544	569	594	619	644	669	694
20	45	70	95	120	145	170	195	220	245	270	295	320	345	370	395	420	445	470	495	520	545	570	595	620	645	670	695
21	46	71	96	121	146	171	196	221	246	271	296	321	346	371	396	421	446	471	496	521	546	571	596	621	646	671	696
22	47	72	97	122	147	172	197	222	247	272	297	322	347	372	397	422	447	472	497	522	547	572	597	622	647	672	697
23	48	73	98	123	148	173	198	223	248	273	298	323	348	373	398	423	448	473	498	523	548	573	598	623	648	673	698
24	49	74	99	124	149	174	199	224	249	274	299	324	349	374	399	424	449	474	499	524	549	574	599	624	649	674	699
25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700

I would like to subscribe to Materials in Design Engineering for ☐ 1 year $3.00 ☐ 2 years $5.00

FIRST CLASS
PERMIT NO. 1538
NEW YORK, N. Y.

BUSINESS REPLY CARD
No postage stamp necessary if mailed in the U. S.

POSTAGE WILL BE PAID BY —

MANAGER, READER SERVICE DEPARTMENT 1161

MATERIALS IN DESIGN ENGINEERING
430 PARK AVENUE
NEW YORK 22, N. Y.

5648PP

MANUAL REPRINTS?

Now you can use these postage-free cards to order reprints of recent M/DE Manuals and Special Reports. Use the list below and circle the appropriate key numbers on the card. You will be billed later—35c for each reprint.* A list of earlier Manuals and Special Reports still available appears on p 172.

*If you prefer to send cash, stamps or check with order, simply put the card in an envelope and mail with remittance.

	CIRCLE KEY NO
Progress in High Temperature Coatings	700
New Ways to Strengthen Metals	699
The Future for Ceramics	698
Prefinished Metals	697
The Role of Materials in Cryogenics	696
New Directions in Mtls Testing (75¢)	695
High Strength Aluminum Alloys	694
What's New in Foam Plastics	693
Chemical Process Equipment Mtls	692
Creep-Rupture	691
What Users Think of Polypropylene	690
Automobile Materials	689
Guide to Ferrous Castings	688
Challenge of the Materials Age ($1)	687
Filament Wound Reinforced Plastics	686
How Radiation Affects Engrg. Mtls	685
Intro. to High Temperature Metals	684
Appliance Materials	683
Why Metals Break	682
Low Cost Coatings for Metal Products	681
Low Pressure Reinforced Plstics	680
The New Welding Processes	679
Mtls for Gaskets, Packings, Seals	678
Impact Thermoplastics	677
Die Castings	676
Adhesive Bonding	675
Guide to Spring Materials	674
Guide to Industrial Textiles	673
Physical Properties and Tests	672
Designing with Metal Powder Parts	671
Organic Coatings for Metal Products	670
Guide to Plastics Selection	669
How to Select a Stainless Steel	668
Sheet Formed Plastic Parts	667
Sleeve Bearing Materials	666
Designing Metal Stampings	665
Paper as an Engineering Material	664
Porcelain Enamels, Ceramic Coatings	663
Designing with Heat Treated Steels	662
New Developments in Ceramics	661
Thermal Insulation Materials	660

Suppliers' Literature
Books, p 49
Reports, p 50

Suppliers' New Bulletins

TFE Products. Allegheny Plastics, Inc., 8 pp, illus., No. R3017. Advantages, characteristics, properties, and other information on molded and fabricated TFE parts. **1**

Vinyl-Aluminum Laminates. Aluminum Co. of America, 20 pp, illus., No. 31-11561. Advantages, characteristics, uses, design information, and a collection of 39 chips showing available color-pattern combinations for vinyl-aluminum laminates. **2**

Synthetic Fiber Felts. American Felt Co., 8 pp, illus., No. 4-61. General descriptions and typical uses for several synthetic fiber felts, including polypropylene, TFE, Dacron, Dynel, rayon, viscose, Orlon and nylon. Includes data on general, physical, chemical, and mechanical properties. **3**

Metallized Ceramics. American Lava Corp., 16 pp, illus., No. 612. Information on high and low temperature metallizing, electroplating, dip coating, design of ceramic-metal assemblies, properties, typical applications, and other information on metallized ceramics. **4**

Precision Casting. Atlantic Casting & Engineering Corp., 18 pp, illus., No. 103. Information on plaster mold casting, investment casting, and how both processes can be combined to overcome important limitations of either process alone. Includes specifications and properties of eight different nonferrous alloys. **5**

Stainless, Nickel, Platinum. J. Bishop & Co. Platinum Works, 69 pp. Series of data sheets give chemical composition, physical and mechanical properties, applications, fabrication data, sizes, and other information on stainless steel and nickel tubular products, platinum and platinum group metal products, and platinum chemicals and catalysts. **6**

Boral Plate. Brooks & Perkins, Inc., 4 pp, illus. General information, formability, typical designs, edge cladding, fabrication and joining data, and other information on boral sandwich-type plate material. **7**

Beryllium Oxide. Brush Beryllium Co., 2 pp. Electrical, thermal, and physical properties of two beryllium oxide bodies for electronic applications. **8**

Transparent Tubing. Busada Mfg. Corp., 4 pp, illus. Information on how to select transparent tubing for specific applications. Includes advantages, characteristics, physical and mechanical properties, sizes, tolerances, and other information on transparent butyrate tubing. **9**

Brass Hexagon Rods. Cerro Corp., Titan Metal Mfg. Co. Div., 2 pp, illus. Advantages, characteristics, uses, sizes, and other information on free-cutting hexagon brass rods used for bolts, nuts, hydraulic and automotive fittings, etc. **10**

Rhenium. Chase Brass & Copper Co., 12 pp, illus. Information on fabrication, applications, price, and available types of rhenium and rhenium alloys for use in the electronics, nuclear, missile, aero-space and electrical fields. **11**

Epoxy Laminates. Continental-Diamond Fibre Corp., 5 pp, No. 11,200B. Electrical and mechanical properties, sizes and thicknesses, tolerances, typical uses, and other information on four grades of glass and paper-epoxy sheets, rods and tubes. **12**

High Temperature Ceramics. Corning Glass Works, Technical Products Div., 6 pp, illus., No. NPC-2. Composition, properties, available sizes, applications and other information on a thin-walled cellular ceramic structure for high temperature uses. **13**

Aluminum Mill Products. Dow Chemical Co., Dow Metal Products Co. Div., 12 pp, No. 141-228-61. Information on aluminum sheet, plate, and extruded products. Includes nominal compositions, available forms, special characteristics, available tempers, thicknesses, widths, lengths, and finishes. **14**

Silicone Compounds. Dow Corning Corp., 8 pp, illus., No. 7-604. Information on the services and facilities available for the development and fabrication of parts made from silicone molding compounds. **15**

Foamed Vinyl. E. I. du Pont de Nemours & Co., Explosives Dept., 6 pp, illus. Advantages, characteristics, typical uses, properties, process description, and other information on foamed vinyls. **16**

Nylon Resins. E. I. du Pont de Nemours & Co., Polychemicals Dept., 24 pp, illus., No. A12931. Advantages, characteristics and properties of several grades of nylon resins. Includes a series of typical applications illustrating nylon's potential use in aircraft, wire and cable, appliances, automobiles, hardware, industry, sporting goods, and business machines. **17**

Polypropylene Wire Coatings. Eastman Chemical Products, Inc., Plastics Div., No. 7. Electrical and physical properties, typical extrusion conditions, and other information on the use of polypropylene for solid and cellular wire coatings. **18**

Metal Finishing, Plating. Enthone, Inc., 6 pp, illus., No. DM61-25-7. Check list describes dozens of metal finishing processes, plating chemicals, and equipment available from this company. **19**

Epoxy Resins. Food Machinery & Chemical Corp., Chemicals & Plastics Div., Epoxy Dept., 6 pp, No. 2. Advantages, characteristics, properties, uses, and other information on epoxy resins and their potential use in high temperature laminates. **20**

Aluminum Specifications. Peter A. Frasse & Co., Inc., Sec. G, No. 1. Chart gives chemical analysis requirements for the most frequently used Federal and Military specifications and the nearest corresponding ASTM, SAE, and AMS numbers. Includes forming and bending data. **21**

Silicone Fluids. General Electric Co., Silicone Products Dept., 20 pp, illus., No. S-9. Guide to use of silicone fluids permits selection of a particular fluid to meet specific property requirements. Includes general descriptions of available silicone fluids, characteristics, properties, applications, etc. **22**

Phenolic, Polyester. Hooker Chemical Corp., Durez Plastics Div., 8 pp, illus., No. D400. Advantages, characteristics, properties, uses, typical applications and other information on phenolic molding compounds, and polyester resins for reinforced plastics, bonding and coating resins, and fire-retardant rigid foams. **23**

Casting Compounds. Hysol Corp., 2 pp, No. DPE-14. General description, properties, handling information, curing information, availability and other information on a flexible flame-out casting compound. **24**

Columbium-Bearing Steels. Jones & Laughlin Steel Corp., 6 pp, illus.,

TECHNICAL LITERATURE

No. AD-295. Advantages, characteristics, properties, uses, forming and joining data, and available forms of a high strength low alloy steel containing columbium instead of carbon and manganese. **25**

Rigid PVC Products. Kaykor Products Corp., 24 pp, illus., No. RV-61. General information, specifications, special advantages and characteristics, available thicknesses and sizes, joining information, properties, chemical resistance, fabrication, and other information on rigid PVC products. **26**

Bronze Alloy. R. Lavin & Sons, Inc., 4 pp, illus. Chemical composition, properties, machinability, corrosion resistance, foundry characteristics, typical applications, and other information on a corrosion resistant bronze alloy. **27**

Vibration Control. Lord Mfg. Co., 16 pp, illus. Information on services, facilities, and products available for the control of vibration, shock, and alloy. **27**

Pearl Pigments. Mearl Corp., 4 pp, illus., No. 6091. Illustrates applications of pearl pigments incorporated into vinyl film and sheeting, molded vinyl and other thermoplastics, and cast acrylics and polyesters. Discusses use of pearl pigments for coating and printing on a wide range of plastics. **29**

Molded Rubber. Mid-Continent Engineering, Inc., Hiawatha Rubber Co. Div., 4 pp, illus. Information on the services and facilities available for the production of moided rubber parts. **30**

Urethane Foam. Mobay Chemical Co., 20 pp, illus. Advantages, characteristics, properties, costs, chemical resistance, and other information on the use of urethane foam for packaging applications. **31**

Plastics Data. Monsanto Chemical Co., Plastics Div., 16 pp, illus. Properties and typical uses of several plastics materials. Includes data on polystyrene, polyethylene, vinyl chloride, and ABS materials. Provides information on available forms, fabricating, extruding, calendering, laminating, coating, and adhesives. **32**

Tubular Braid. National-Standard Co., 4 pp, illus., No. TB301. Latest applications, standard terminology, and available types of tubular and flat metal braid constructions for such applications as flexible metal tubing reinforcement, electrical shielding for high frequency cables, etc. **33**

Urethane Insulation. Nopco Chemical Co., Plastics Div., 4 pp, illus. Advantages, characteristics, properties, uses, and other information on urethane foam insulation for sub-zero applications. **34**

Nuclear Materials. Nuclear Materials & Equipment Corp., 30 pp, illus. Information on services and facilities available for the production of special materials and equipment for the nuclear industry. **35**

Molded Plastics. Patent Button Co., 16 pp, illus. Information on the services and facilities available for the production of custom molded plastics products. **36**

TFE-Lined Tubing. Pennsylvania Fluorocarbon Co., Inc., 2 pp, illus., No. 1-RR. Advantages, characteristics, sizes, and other information on TFE-lined rubber tubing for food, chemicals, pharmaceuticals, electrical and electronic cabling, etc. **37**

Metal Alloys. H. K. Porter Co., Inc., Riverside-Alloy Metal Div. Outstanding characteristics, available forms, typical uses, and other information on copper-base, stainless steel, and nickel-base alloys. **38**

Steel Tubing. Republic Steel Corp., Steel & Tubes Div., 60 pp, illus., No. STR-1. Advantages, characteristics, uses, sizes and thicknesses, tolerances, properties, and design data for round, square, and rectangular carbon steel structural tubing. **39**

Molded, Laminated Plastics. Richardson Co., 12 pp, illus. Information on the services and facilities available for the production of laminated plastic rod, tube, sheet, and moldings. **40**

Formable Plastic Sheets. Seiberling Rubber Co., Plastics Div., 4 pp, illus., No. 320-B. General information, outstanding characteristics, availability, packaging information, typical uses, and other information on formable sheets made of rigid PVC, rigid vinyl copolymers, ABS materials, polyethylene, polypropylene, and polystyrene. **41**

Vacuum Metallizing. F. J. Stokes Corp., 16 pp, illus., No. 584. Advantages, characteristics, typical uses, specifications for equipment, and other information on vacuum metallizing of glass, paper, metal, or plastics surfaces. **42**

Glass-Epoxy Laminates. Taylor Fibre Co., 4 pp, Nos. 51.5.20 and 51.5.21. Specifications, characteristics, properties, sheet sizes and thicknesses, and other information on a flame-retardant glass-base epoxy laminate. **43**

Diffusion Coatings. Haynes Stellite Co., Div. of Union Carbide Corp., 8 pp, No. F-30,190B. Oxidation and corrosion resistance, hot hardness, impact strength, short-time tensile data, thermal shock data, flame errosion data, and fatigue strength of high temperature alloys protected by nickel and aluminum diffusion coatings. **44**

Molded, Fabricated TFE. U. S. Ceramic Tile Co., Sparta Mfg. Co. Div., 6 pp, illus., No. SM-100. Information on molding, coating, die cutting, and machining TFE parts. Includes a chart of physical and mechanical properties. **45**

Alumina Ceramics. U. S. Stoneware Co., Alite Div., 8 pp, illus., No. A-8. Advantages, characteristics, physical and mechanical properties, electrical characteristics, chemical resistance, joining methods, dimensional tolerances, and other information on high alumina ceramic parts. **46**

Ultra-High Strength Steel. Vanadium-Alloys Steel Co., 20 pp, illus. Detailed data on heat treatment, properties, fabrication, welding, applications, hardenability, etc., of a new ultra-high strength steel with tensile strength values above 360,000 psi. **47**

Metallizing Powders. Wall Colmonoy Corp., Hard Facing Div., 2 pp, illus., No. T-3. General information on metallizing and powders available. Lists properties and characteristics of several formulations. **48**

Metals Facility. Westinghouse Electric Corp., Materials Mfg. Dept., 20 pp, illus., No. B-6570. Information on new services and facilities available for the production of new wrought alloys and molded metal products. Includes facilities for investment and shell mold castings, heat treating, powder metallurgy, etc. **49**

Other Available Bulletins

Irons & Steels • Parts • Forms

Ferrous Forgings. American Brake Shoe Co., AmForge Div., 28 pp, illus. Facilities and services available for the production of drop, upset and press forgings. **50**

Vinyl-Metal Laminate. American Nickeloid Co., 6 pp, illus. Specifications, uses and fabrication of vinyl-metal laminate sheets, strips and cuts. **51**

Wire Parts, Small Stampings. Art Wire & Stamping Co., 4 pp, illus. Shows a variety of wire parts and small metal stampings in both ferrous and nonferrous metals. **52**

Metallurgy of Tubing. Babcock & Wilcox Co., Tubular Products Div., 36 pp, illus. Series of short articles give information on such things as high temperature applications of tubing, elevated temperature strength, machinability, nondestructive testing, stress corrosion cracking, effects of alloying elements, residual stresses, heat treatment, hardenability, mechanical properties, etc. **53**

Porcelain Enameling Steel. Bethlehem Steel Co., 4 pp, illus., No. 718. General information, typical mechan-

ical properties and uses of steel sheet for porcelain enameling. **54**

Investment Castings. Casting Engineers, Inc., 84 pp, illus. Design considerations, castable metals and alloys, tolerances, and costs of conventional investment castings and miniature precision cast parts. **55**

Self-Lubricating Bearings. Chrysler Corp., Amplex Div., 4 pp, illus. Uses, performance data and mechanical properties of self-lubricating Iron Oilite bearings. **56**

Steel Tubing. Copperweld Steel Co., Ohio Seamless Tube Div., 8 pp, illus., No. CS-61. Characteristics, applications, sizes, secondary operations, advantages, tolerances, specifications, and other information on seamless and welded steel tubing. **57**

Metal Powders. Crane Co., Metals Div., 12 pp, illus., No. 2. Production methods, general characteristics and uses of iron, nickel, manganese, silicon and ferro-alloy powders. **58**

Metal Stampings. Dayton Rogers Mfg. Co., 8 pp, illus, No. F-185. Information on services and facilities available for the production of small lot precision metal stampings. Includes design hints, costs and suggestions for converting various parts to stampings. **59**

High Alloy Castings. Duraloy Co., 20 pp, illus., No. G-159. Physical properties of corrosion resistant, heat resistant and abrasion resistant high alloy used for static, centrifugal and shell molded castings. **60**

Stainless Steel. Eastern Stainless Steel Corp., 22 pp, illus. Information on the services and facilities available for the production of stainless steel sheet, plate, strip, and coils. Includes chemical compositions of most common stainless types, and available thicknesses, widths, and lengths of sheet and plate. **61**

Metal Powder Parts. Eaton Mfg. Co., Powdered Metals Div., 8 pp, illus., Vol. 18, No. 2. Article discusses metal powder parts in general, several methods of producing them, equipment and facilities required, heat treatment of iron powder parts, and mechanical properties of various iron powders. **62**

Rolled Steel Rings. Edgewater Steel Co., 12 pp, illus. Describes and illustrates a process by which rolled steel rings are formed from solid blocks. **63**

Ultra Thin Strip. Hamilton Watch Co., Metals & Electronics Div., 2 pp, illus. Services and facilities available for the production of ultra thin metal strip. Included is information on materials available, special alloys, and sizes and tolerances. **64**

Prealloyed Powders. Hoeganaes Sponge Iron Corp., 4 pp, illus., No. 128. Advantages, characteristics, properties, and uses of prealloyed stainless steel and high alloy powders. **65**

Stainless Steel Wire. Jones & Laughlin Steel Corp., Stainless & Strip Div., 22 pp, illus. Technical data and other information on how to use and order stainless steel wire. **66**

Steel Plate Shapes. Lukens Steel Co., 16 pp, illus., No. 378. Information on facilities available for flame cutting, shearing, blanking, punching, pressing, bending, and welding various shapes made from steel plates. **67**

Metal Castings. Meehanite Metal Corp., 4 pp, illus., No. 32. Physical, mechanical and thermal properties of general and heat resisting Meehanite metal castings. **68**

Porous High Temperature Metals. Mott Metallurgical Corp., 4 pp, illus. Information on new, controlled porosity of stainless steel, etc., opening up new parameters for precision products in flat stock or intricate shapes. **69**

Metal Stampings. Reichert Float & Mfg. Co., 8 pp, illus. Shows facilities for special forming and deep drawing intricate, light and heavy metal stampings. **70**

Roll Formed Shapes. Roll Formed Products Co., 32 pp, illus., No. 760. Information on roll forming techniques, design, decorative finishes, precision, punching and notching, typical applications and standard angles and channels. Includes sketches of profiles and sizes available. **71**

Welded Steel Tubing. Standard Tube Co., 4 pp. Describes the advantages of welded carbon steel tubing over solid bars. Includes information on weight per ft, sizes and thicknesses, minimum physical properties, torque values, and other advantages. **72**

Air Hardening Tool Steel. Timken Roller Bearing Co., Steel & Tube Div., 4 pp, illus. Advantages, characteristics, properties, heat treatment, typical uses, and other information on an air hardening tool steel. **73**

Cold Formed Parts. Van Huffel Tube Corp., 48 pp, illus. Information on cold formed metal parts. **74**

Cutting Tool Alloy. Vascoloy-Ramet Corp., 12 pp, illus., No. 6102. Characteristics, advantages, properties, available types, uses, cutting speeds, and other information on a series of cobalt, chromium, tungsten, columbium, and carbon cutting tool alloys. **75**

Corrosion Resistant Castings. Waukesha Foundry Co., Castings Div., 18 pp, illus. Information on the services and facilities available for the production of corrosion resistant castings. Includes data on compositions, mechanical properties, and corrosion resistance. Also covers specifications and properties of special casting alloys. **76**

Expanded Metals. Wheeling Corrugating Co., 8 pp, illus., No. WC-227. Advantages, characteristics and available types of regular and flattened expanded metals. **77**

Superalloy Forgings. Wyman-Gordon, 4 pp, illus. Composition, heat treatment, mechanical and physical properties, typical applications, materials used, and other information on superalloy forgings. **78**

Cold Rolled Metal. Yoder Co., 88 pp, illus. Use of cold formed moldings, trim and tubular shapes in a number of products. **79**

To get suppliers' free literature use prepaid post card on pp 41 and 42.

Nonferrous Metals

• *Parts* • *Forms*

Zinc, Aluminum Die Castings. Advance Tool & Die Casting Co., 6 pp, illus. Chemical composition and physical properties of zinc and aluminum alloys used in the manufacture of die castings. **80**

Insulated Wire. Aero Research Instrument Co., Inc., No. 4. Advantages; sizes; uses; and descriptions of sheath materials, insulation and wires for use up to 3000 F. **81**

Metal Powders. Metals Disintegrating Co., Div. of American-Marietta Co., illus. Description, specifications, properties and uses for all types of metal powders. **82**

High Strength Aluminum Alloy. American Smelting & Refining Co., Federated Metals Div., 6 pp, illus. Physical and mechanical properties, specifications, composition and foundry characteristics of a high strength aluminum casting alloy that requires no heat treatment. **83**

Beryllium Copper Rod. Beryllium Corp., 8 pp, illus., No. R-1200-A. Advantages, characteristics, physical and mechanical properties, available sizes, standard tolerances, weight tables, and other information on beryllium copper rod. **84**

Integral Finned Tube. Calumet & Hecla, Inc., Wolverine Tube Div., 24 pp, illus., No. 8027. Information on metals and composites available, sizes and tempers, specifications, tolerances, typical uses, ordering, and other data on integral finned tube. **85**

Nickel-Base Alloy. Cannon-Muskegon Corp., 9 pp, illus., No. 86. Thermal conductivity, oxidation resistance, formability, and yield and tensile strength of a vacuum melted nickel-base alloy called René 41. **86**

Ferrous, Nonferrous Tubing. Damascus Tube Co., 46 pp, illus. Chemical composition, physical and mechanical properties, and corrosion resistance of zirconium, titanium, nickel-base alloys, and stainless steels used in the manufacture of pipe and tubing. **87**

Die Castings. Dollin Corp., 16 pp, illus. Facilities for die casting large and small parts of zinc and aluminum. **88**

Tungsten, Molybdenum. General Electric Co., Lamp Metals & Components Dept., 80 pp, illus. Properties, structure, finishes, uses, availability, and prices of tungsten and molybdenum metal powders, rod, and wire. **89**

Resistance Alloy. Hoskins Mfg. Co., 8 pp, illus., No. 112. Properties and performance characteristics of an

TECHNICAL LITERATURE

iron-chromium-aluminum resistance alloy for use as heating elements at temperatures below 2050 F. **90**

Nonferrous Castings. Ohio Precision Castings, Inc., 16 pp, illus. Information on castings made from brass, bronze, aluminum and beryllium copper. **91**

Aluminum Rod. Olin Mathieson Chemical Corp., Metals Div., 8 pp, illus., No. 22. Information on cold processed aluminum rod and screw machine stock. Discusses advantages, characteristics, typical properties, and typical finishes. **92**

Zinc, Aluminum Die Castings. Paramount Die Castings Co., 6 pp, illus. Examples of typical zinc and aluminum die castings. **93**

Deep Drawn Shapes. Pressed Steel Tank Co., 2 pp, illus. Information on cylindrical, spherical, conical and tapered deep drawn shapes and shells made of ferrous and nonferrous metals. **94**

Vinyl-Metal Laminates. Simoniz Industrial Prod. Div., Simoniz Co., 8 pp, illus. Gives physical, chemical and thermal properties, and abrasion resistance of vinyl-metal laminates. **95**

Tin Plated Strip. Somers Brass, Inc., 1 p, illus. General information on tin plated thin strip metals. **96**

High Temperature Metals. Super-Temp Engrg. & Mfg., Inc., 4 pp, illus. Series of photographs illustrate typical parts now being forged from pure tungsten, molybdenum and molybdenum-tungsten billets. **97**

Nickel, Plated and Clad Wire. Sylvania Electric Products Inc., Parts Div., 6 pp. Chemical composition, and physical, mechanical and electrical properties of nickel, nickel alloy, stainless steel, plated and clad wire. **98**

Thermostat Metal Calculator. Texas Instruments, Inc., Metals & Controls Div., 8 pp, No. TRU-8A. Nomograph calculator allows determination of thermal deflection and restrained force of elements in simple beams, cantilever beams, spiral and helix coils, and u-shapes of various lengths and thicknesses made of thermostat metals. **99**

Spherical Powders. Union Carbide Corp., Linde Co. Div., 8 pp, illus., No. 1402. Description of a new process for producing spherical powders of metals and alloys in sizes ranging from 5 to 150 microns. Covered are physical data, powder composition, availability and prices, applications, and other information on copper, aluminum, nickel, stainless steel, tungsten and Nichrome-V spherical powders. **100**

Molybdenum. Universal-Cyclops Steel Corp., 22 pp. Chemical composition, structure, mechanical properties, dimensions, finish, inspection and other information on unalloyed molybdenum and molybdenum alloy billets, bars, plates and sheets. **101**

Metals, Ferroalloys. Vanadium Corp. of America, 8 pp. Chemical compositions and applications of more than 90 different ferroalloys, metals and chemicals. Among the many metals described are various alloys of aluminum, iron, chromium, columbium, manganese, silicon, titanium, and vanadium. **102**

Plastics & Rubber • Parts • Forms

Polyester Resins. American Cyanamid Co., Plastics & Resins Div., 8 pp, Jan '61. Characteristics, advantages, available types, uses, operating procedures, safety, coloring, and other information on polyester resins for spray-up application. **103**

Molded Polyester. Atlas Chemical Industries Inc., 4 pp, illus. Characteristics, costs and advantages of molded reinforced polyester parts used in a centrifugal pump. **104**

Acrylic-Type Polymer. J. T. Baker Chemical Co. Properties and uses of an acrylic-type polymer suitable for injection molding and extrusion. **105**

ABS Plastics. Marbon Chemical Div., Borg-Warner Corp., illus. Advantages, characteristics, properties, and other information on the use of ABS plastics for automobile interior components, including steering wheels, dash panels, seat shells, trunk liners, etc. **106**

Nylon Bearings. Bunting Brass & Bronze Co., No. 32. Information on solid rods, extruded tubes, tubular bars, pressure tubing, and plate. **107**

Corrosion Resistant Plastics. Ceilcote Co., Inc., 4 pp, illus., No. 1-2. Advantages, characteristics, properties, chemical resistance, and uses of corrosion resistant reinforced plastics linings, coatings, floorings, process equipment, cements, and ventilating equipment. **108**

High Density Polyethylene. Celanese Polymer Co. Div., Celanese Corp. of America, 10 pp, illus., No. P2A. Series of typical applications show the advantages of high density polyethylene for such things as toys and sporting goods, housewares, bottles, containers and closures, textile applications, industrial applications and film. **109**

Hardener for Epoxy Resins. Ciba Products Corp., 10 pp, illus., No. 25. Typical properties, applications, pot life and curing cycles of a safety hardener for epoxy resins. **110**

Rubber Compounds and Moldings. Colonial Rubber Co., 16 pp, illus., No. C-60. General information on services and facilities available for producing rubber compounds and rubber moldings for a wide variety of uses. **111**

Plastics Data Sheets. Conneaut Rubber & Plastics Co. Series of data sheets cover nine of the most widely used thermoplastic materials, including vinyls, polyethylene, styrenes, butyrate, nylon, chlorinated polyether, and ABS polymer. Includes data on typical uses; physical, electrical and chemical characteristics; and sizes, forms, and available colors. **112**

Rubber Products. Continental Rubber Works, Inc., 8 pp, illus., No. 3/BCO. Services and facilities available for the preparation of raw materials, and the design and production of rubber parts. Includes discussions of finishing and inspection, design, and typical extruded and molded rubber parts. **113**

Plastics Films. E. I. du Pont de Nemours & Co., Inc., Film Dept., 8 pp, illus., No. A-12703. Advantages, characteristics, properties, and typical uses of several industrial plastics films, including polyester, polyvinyl-fluoride, polyethylene, fluorocarbon, cellophane, and acetate. **114**

Plastics Properties. Fiberite Corp. Comparative chart for compression molders and transfer molders lists mechanical, electrical and thermal properties of all general purpose thermosetting plastics materials. **115**

Laminated Plastics. General Electric Co., Laminated Products Dept., 16 pp, illus., No. L-CDL-494. Applications, available sizes, grades and properties of laminated plastics sheet, tube and rod. **116**

Vinyl Resins. Goodyear Tire & Rubber Co., Chemical Div., 4 pp. Properties and uses for medium and low viscosity, general purpose vinyl resins. **117**

Injection Molded Acetal. Gries Reproducer Corp., 8 pp, illus., No. 1001A. Characteristics, advantages, properties, typical uses, and other technical information on tiny injection molded acetal parts whose maximum size and length are 0.03 oz and 1¼ in., respectively. **118**

Nylon Parts. Nylon Molded Products Corp,. 4 pp, illus. Describes a method for calculating the materials cost of a nylon part. **119**

Polyethylenes. Phillips Chemical Co., Plastic Sales Div., 4 pp. Properties, special characteristics, suggested applications, and complete prices of low, medium, and high density polyethylenes. **120**

Phenolics. Plastics Engineering Co., 16 pp, illus. General information on phenolic molding compounds, including available colors, range of properties and typical advantages and applications. **121**

Filled Nylon. Polymer Corp., Molding Resins Div., 4 pp, illus., No. GS-2. Series of case histories illustrate advantages and characteristics of a nolybdenum disulfide-filled nylon molding compound. Included is a chart of physical properties. **122**

Fabricating Plastics Parts. Sinko Mfg. & Tool Co., 4 pp, illus. Facilities for injection molding, vacuum distilla-

tion plating, hot stamping, painting and assembly of plastic parts. **123**

Rubber Stocks. Stalwart Rubber Co., 16 pp, illus. Information on type of rubber stocks from which company fabricates precision parts. **124**

Polysulfide Rubber. Thiokol Chemical Corp., 8 pp, No. PS-1. Results of a study undertaken to define the resistance of polysulfide rubber to halogenated hydrocarbon fluids. Covers test procedures and materials used, and compares polysulfide with other elastomers. **125**

Sponge Rubber. U. S. Rubber Co., U. S. Kem-Blo Sponge Dept., 4 pp, illus. Applications, dimensions and specifications for various types of sponge rubbers. **126**

Mechanical Rubber Goods. Williams-Bowman Rubber Co., 6 pp, illus. Information on the services and facilities available for the production of mechanical rubber goods. **127**

Other Nonmetallics • Parts • Forms

Properties of Felt. Continental Felt Co., 12 pp, illus. General, physical, mechanical, and chemical properties; fabricating methods; typical uses; relative prices, and an alphabetical list of hundreds of felt applications keyed to specific properties. **128**

Graphite. Great Lakes Carbon Corp., Electrode Div., 8 pp, illus. Outstanding characteristics, chemical composition, properties, and typical applications of graphite in atomic energy, metallurgy, metal fabricating, aircraft, chemical processing, etc. **129**

Silica, Glass Fibers. Johns-Manville Sales Corp., Industrial Insulation Div., 4 pp, illus., No. IN-330A. General information, availability, properties, sizes, and other information on high temperature silica and glass fibers for insulation and reinforcement. **162**

Glass Products. Lancaster Glass Corp., 28 pp, illus. Case histories on the use of glass in television tubes, auto dome lights, desk sets, refrigerator lights and vending machines. **130**

Lignum-Vitae. Lignum-Vitae Products Corp., 9 pp, illus. Engineering and design data, and case histories on industrial uses of lignum-vitae. **113**

Industrial Ceramics. McDanel Refractory Porcelain Co., 4 pp, illus. Briefly describes ceramic pump pistons, combustion tubes, heat reflectors, crucibles and liners. **132**

Glass-Bonded Mica. Molecular Dielectrics, Inc., 4 pp, illus. Advantages, characteristics, electrical and mechanical properties, fabrication data, applications, available sizes and grades, and prices of glass-bonded mica substrates and printed circuits. **133**

Coated Fabrics. Reeves Brothers, Inc., Vulcan Div., 12 pp. Physical properties, performance characteristics, and typical applications of more than 200 different styles of rubber-coated fabrics. **134**

Ultra Pure Graphite. Speer Carbon Co., Carbon Products Div. Information on purity limits, available sizes, physical properties, and applications of a line of ultra pure graphites. Includes information on both molded and extruded forms. **135**

Heat Reflection. Thermo-Chem Corp., 4 pp. High and low temperature barrier capabilities, strength, abrasion resistance and other information on a process capable of imparting heat reflection properties to ordinary textiles, fabrics, paper, felt, rubber, plastics and leather. **136**

Thermal Insulation. H. I. Thompson Fiber Glass Co., chart. Information on insulations for temperatures from –300 F to 3000 F. **137**

Finishes • Cleaning & Finishing

Corrosion Inhibitor. Allied Chemical Corp., Solvay Process Div., 17 pp, illus. Use of sodium nitrite in corrosion prevention. **138**

Chromium Diffusion Coating. Alloy Surfaces Co., 24 pp, illus., No. CW 6-60. Information on a new process for diffusing chromium into stainless steel. Includes a description of the process and equipment, and characteristics, properties, costs, and typical applications of coated steel. **139**

Silver Electroplates. Englehard Industries, Inc., American Platinum & Silver Div., 4 pp. Tells how to silver plate ferrous and nonferrous metals. **140**

Metallized Ceramic Coating. Frenchtown Porcelain Co., 4 pp, illus. Data on Molcote, metal-to-ceramic coating, that may be hard soldered up to 2200 F. **141**

Removable Protective Coating. Industrial Metal Protectives, Inc., 1 p. Characteristics, advantages, uses, and other information on a transparent protective coating that is easily removed. **142**

Coatings for Mirrors. Libby-Owens-Ford Glass Co., Liberty Mirror Div., 32 pp. Reflectivity, adherence, hardness, durability, water resistance, effect of temperature and other information on a line of coatings for mirrors. **143**

Multicolor Enamel. Maas & Waldstein Co., 2 pp, No. 520. Data sheet for industrial multicolor enamels. **144**

Hard Surfacing Electrodes. Metal & Thermit Corp., Unichrome Finishes & Welding Prod. File cards give data on 88 types and sizes of hard surfacing electrodes and rods. **145**

Metallized Coatings. Metco, Inc., 6 pp, illus., No. 15. Series of case histories illustrate advantages, characteristics, uses, and economics of flame spray metallizing. **146**

Silicone-Base Coatings. Midland Industrial Finishes Co., 4 pp, illus. Heat, chemical and corrosion resistance, application data and uses of silicone-base coatings. **147**

Metal Cleaners. Northwest Chemical Co., 4 pp. Information on immersion, electrolytic and spray cleaners for die castings, steel, copper and aluminum. **148**

Chromium Coatings. Pennsalt Chemicals Corp., 12 pp, No. MP-627. General information, advantages, characteristics, physical properties, typical uses, methods of applying and other information on a chromium corrosion resistant coating. **149**

Joining & Fastening

Welding Aluminum. Oakite Products, Inc., 8 pp, illus., No. F11026. Information on the chemical preparation of aluminum for resistance welding. Discusses various cleaning compounds and outlines four specific weld preparation procedures. **150**

Bolts, Forgings. Rhode Island Tool Co., 26 pp, illus., No. 75. Dimensions, properties, prices and uses for drop and upset forgings, eye and special bolts, studs, cap screws, and nuts. **151**

Lock Screw Fasteners. Russell, Burdsall & Ward Bolt & Nut Co., 3 pp, illus. Advantages and dimensions of spin-lock screws. **152**

Speed Nuts. Tinnerman Products, Inc., 18 pp, illus., No. 353. Seventeen case histories describe assembly saving achieved through the use of Speed Nut mechanical fasteners. **153**

Nylon Screws. Weckesser Co., 3 pp, illus. Installation data for black nylon screws and nuts. **154**

Methods & Equipment • Testing

Hardness Tester. Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., 2 pp, illus., No. TT-58. Dimensions, features, operational data and prices of a Rockwell hardness tester. **156**

Induction Heating. Lepel High Frequency Laboratories Inc., 12 pp, illus., Vol. 1, No. 6. Information on the use of induction heating equipment in zone refining, zone leveling and crystal growing. **159**

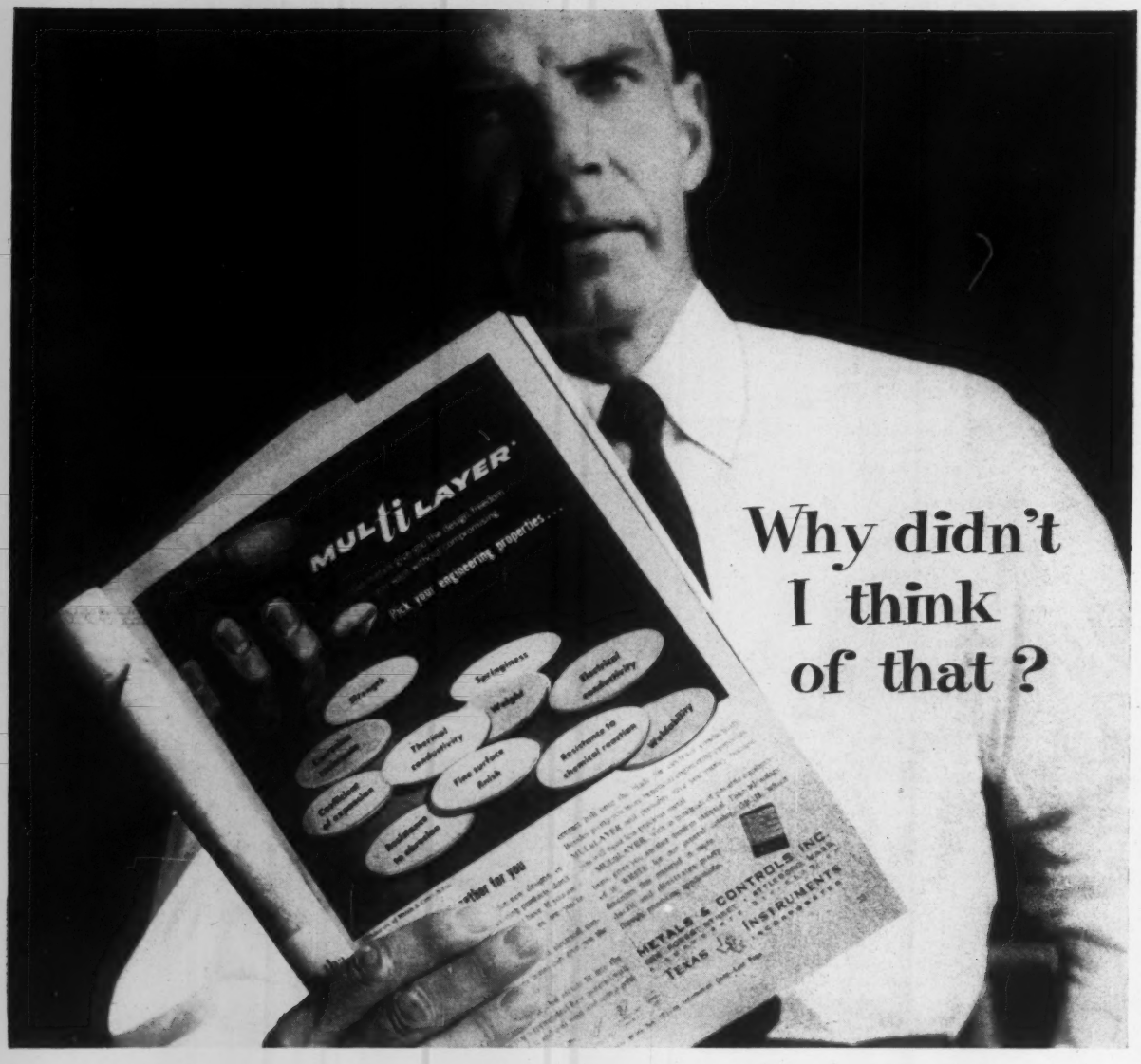
Testing Machines. Scott Testers Inc., 6 pp, illus. General characteristics, advantages, and specifications of a tensile elongation tester. **160**

Temperature Indicators. Tempil Corp., 1 p, illus., No. 5910TS. Information on a complete line of available temperature indicators, including instructions for use. Covers such things as checking temperatures of rotating parts, visibility on brightly radiating hot surfaces, and effects of reducing atmospheres in electrical fields. **161**

CORRECTION

A previous literature review of Johns-Manville's high temperature fibrous insulation inadvertently referred to silicone fibers. This should have been silica. See item 162 above for correct version.

Turn to page 49 for current books and reports→



MULtiLAYER* Clad Metals Combine The Exact Operating Properties I Must Have.

This design engineer has just realized a fact we wish more people would discover. MULtiLAYER CLAD METALS PROVIDE MORE COMBINATIONS OF OPERATING CHARACTERISTICS THAN ANY SINGLE MATERIAL OR ALLOY.

If you need a spring with high conductivity, superior elastic properties, high temperature strength and easy weldability, no single spring alloy can satisfy all the requirements. MULtiLAYER clad spring metals can!

If a tube for chemical processing must have a clean, corrosion resistant, stainless steel surface, high thermo conductivity, plus high forming ductility for flaring and bending; no single material can satisfy all these requirements. MULtiLAYER clad tubing can!

Therefore, why compromise? Why be limited to only partial reliability in your components when, with MULtiLAYER clad metals, you can get maximum satisfaction?

You specify the engineering properties you need . . . we'll put the metals together for you — and even make the components in many cases. Find out about this modern design material. Call us or write for our illustrated brochure GP-1.

For materials and components come to Metals & Controls

*Trademark of Metals & Controls Inc.

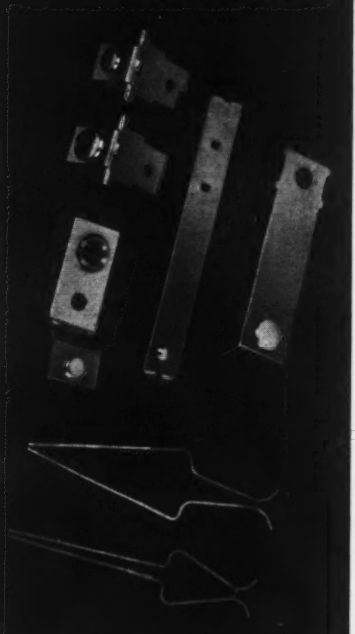
TUBING · WIRE · STRIP · STAMPINGS · BALL WELDED ASSEMBLIES · CONTACTS · THERMOSTATIC METALS · YOU NAME IT!

METALS & CONTROLS INC.
1611 FOREST ST. • ATTLEBORO, MASS.
A CORPORATE DIVISION OF
TEXAS INSTRUMENTS
INCORPORATED

For more information, turn to Reader Service card, circle No. 381

MULtiLAYER*

Welded Assemblies Eliminate RIVETS & BUTTONS



*A Trademark of Metals & Controls Inc.

Take a strip of spring steel, clad an overlay of copper to it, weld and coin a precious metal ball at the exact contact point. The result . . . a MULtiLAYER relay part with operating qualities impossible to obtain through the use of any single alloy or plated material. When blanked and cut off, this part gives you maximum reliability, peak performance without compromise, occupies a minimum of space and costs a fraction of parts made by conventional methods. Especially when produced in quantity by our time-proven direct cladding methods, four-slide presses and custom designed welding equipment.

Similar parts from wire, inlay and overlay strip, and other MULtiLAYER clad metals produce the same benefits. Our field engineers in your territory will help you apply this modern design material to your products. Write, call, or wire Marketing Manager, Precision Electrical Parts Dept.

METALS & CONTROLS INC.

1611 Forest St., Attleboro, Mass.

A corporate division of

TEXAS INSTRUMENTS INCORPORATED

TECHNICAL LITERATURE

(cont'd from p 47)

Books

The Machining of Steel. *F. C. Lea and Eric N. Simons. Macmillan Co., New York. 1961. Cloth, 5½ by 8½ in., 208 pp. Price $5*

This book discusses the fundamental principles of cutting and shaping steel and its alloys, and such associated subjects as speeds, feeds, coolants, jigs, fixtures, and gauges.

Specific subjects include turning, planing, shaping, milling, drilling, broaching, reaming and sawing. Of special interest is a discussion of electro-spark cutting—a new technique used to cut hard metals.

Powder Metallurgy. *Edited by Werner Leszynski. Interscience Publishers, Inc., New York. 1961. Cloth, 6 by 9¼ in., 847 pp. Price $25*

This book consists of papers presented at a recent international conference held under the joint sponsorship of the Metal Powder Industries Federation and the Powder Metallurgy Committee of the Institute of Metals Div., AIME.

The book is broken down into four main sections: Mechanisms of Sintering, Dispersion Strengthening, Technology and Methods, and Materials and Applications. Subjects of special interest include: theory of solid state sintering, role of interparticle contacts in sintering, kinetics of hot pressing, sintering behavior of organic materials, theory of dispersion hardening, dispersion-strengthened steel, large sintered bodies and parts, slip casting, explosive forming, hot extrusion of metal powders, recent trends in European metal powder parts manufacture, sintered high temperature alloys, and titanium, zirconium and beryllium.

ASTM Books on Materials. *American Society for Testing Materials, Philadelphia.*

Elevated Temperature Properties of Aluminum and Magnesium Alloys. *Special Technical Publication No. 291. 1960. Paper, 8½ by 11 in., 308 pp. Price $7*

Summarizes elevated temperature tensile and creep-rupture properties of commercially available aluminum and magnesium alloys that would normally be used at elevated temperatures. Covers both wrought and cast alloys, and includes designations, chemical compositions, and pertinent specifications under which various forms of the material are supplied.

Reinforced Plastics for Rockets and Aircraft. *Special Technical Publication No. 279. 1961. Cloth, 6 by 9 in., 140 pp. Price $5.50*

This book attempts to summarize what is known about design, fabrication, quality control, and testing of reinforced plastics. Some subjects covered are: evaluation of reinforced plastics for high temperature structural applications, permeability of materials under high pressure and at various temperatures, principles and capabilities of ablation, and testing materials under ablative conditions.

Symposium on Adhesion and Adhesives. *Special Technical Publication No. 271. 1961. Cloth, 6 by 9 in., 66 pp. Price $2.25*

Although this volume makes no attempt to be a complete study of the problems relating to adhesives, it does answer many of the questions raised by engineers who have not used adhesives for metal applications. The point of the book is to "give impetus to the use, technology, and testing of all adhesives." Some subjects of special interest: elevated-temperature-resistant metal-to-metal adhesive bonds, ceramic adhesives, and how loading rate affects tensile shear strength of adhesive-bonded metal.

Symposium on Nondestructive Testing in the Missile Industry. *Special Technical Publication No. 278. Cloth, 6 by 9 in., 71 pp. Price $2.00*

Particular emphasis is placed on 1) establishing a background of unclassified literature on a limited number of specific applications of nondestructive testing; and 2) outlining many of the present nondestructive testing problems remaining to be solved. Subjects include: high energy radiography, radiography of weldments in motion, ultrasonic inspection of adhesive-bonded aluminum sandwich structures, and ultrasonic standards for evaluating missile materials and components.

1960 Supplements to Book of ASTM Standards. *Paper, 6 by 9 in. Price $4 each*

These ten supplements provide latest information on standard specifications, tests, definitions, and recommended practices for all engineering materials covered in the

PROTECTIVE COATINGS FOR PARTS & PARTICLES BY NUMEC

COMMERCIALLY AVAILABLE FROM NUMEC —A LARGE NUMBER OF METALLIC AND NON-METALLIC coatings on base materials.

TYPICAL COATING MATERIALS— Silicides • Borides • Carbides • Nb • V • W • C (pyrolytic) • Mo • Be • Cr • Si • Ni • Cu • BeO • Al_2O_3 • SiO_2 (Duplex and alloy coatings also available)

TYPICAL BASE MATERIALS— UO_2 • UC • U metal • ThO_2 • WC • BeO • SiO_2 • C • glass • steels • alloys • semi-conductors • carbides refractory metals • graphite

NUMEC's high density, adherent coatings can be applied to base materials including fine powders, spheres, pellets, tubing, plates, sheet, and other more complex configurations. For information or estimates on your coating requirements contact:

NUMEC®

Nuclear Materials & Equipment Corporation

Apollo, Pa. Phone: GRover 2-8411

Cable: NUMEC TWX: APO-276

For more information, circle No. 469

TECHNICAL LITERATURE

Book of ASTM Standards. The information is either new or completely revised.

Compilation of Chemical Compositions and Rupture Strengths of Super Strength Alloys. *Paper, 8½ by 11 in., 12 pp. Price $1.50*

Includes all known high temperature, super strength alloys, including some no longer in commercial production and several experimental alloys.

1959 Digest of Literature on Dielectrics, Vol. 23. *Edited by L. J. Frisco and T. D. Callinan. National Academy of Sciences, National Research Council, Washington, D. C. 1960. Paper, 8½ by 11 in., 423 pp. Price $8*

This comprehensive digest of technical publications on the theory and applications of dielectrics was prepared by 38 experts and contains information on virtually all aspects of dielectrics and related subjects. Each of its 12 chapters contains an extensive bibliography and substantial digests of articles and publications on such subjects as instrumentation and measurements, dipole moments and dielectric relaxation times, molecular and ionic interactions, conduction phenomena, breakdown, ferroelectric and piezoelectric materials, magnetic materials, plastics and rubber insulation, insulating films and fibrous materials, insulating liquids and their applications, solid inorganic insulation, and tables of dielectric constants.

Reports

Tantalum alloys TANTALUM AND TANTALUM ALLOYS. *F. F. Schmidt, Defense Metals Information Center, Battelle Memorial Institute. Jul '60. 344 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $5 (PB 151 091)*

A survey of process metallurgy, binary and ternary alloy systems, and physical, chemical and metallurgical properties.

High temperature ceramics STABILITY OF CERAMIC MATERIALS AT TEMPERATURES TO 2000 C. *J. Berkowitz, Wright Air Development Div., U. S. Air Force. Sept '60. 68 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.75 (PB 171 405)*

Titanium design data Three separate reports provide design information and properties for titanium alloys. All are available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C.

DESIGN INFORMATION ON TITANIUM ALLOYS FOR AIRCRAFT AND MISSILES. *W. P. Achbach and R. J. Favor, Defense Metals Information Center, Battelle Memorial Institute. Jan '61. 84 pp. Price $2.25 (PB 151 104)*

Tension, compression, bearing, and shear properties, and the effects of temperature for wrought titanium and its alloys.

A STATISTICAL SUMMARY OF MECHANICAL PROPERTY DATA FOR TITANIUM ALLOYS. *W. S. Lyman, Defense Metals Information Center, Battelle Memorial Institute. Feb '61. 23 pp. Price 50¢ (PB 161 237)*

Discusses alpha and alpha-beta titanium alloys produced and tested from 1957 to 1960. Histograms and charts describe mechanical properties in various conditions.

SUMMARY OF PRESENT INFORMATION ON IMPACT SENSITIVITY OF TITANIUM WHEN EXPOSED TO VARIOUS OXIDIZERS. *W. K. Boyd, Defense Metals Information Center, Battelle Memorial Institute. Mar '61. 7 pp. Price 50¢ (PB 161 239)*

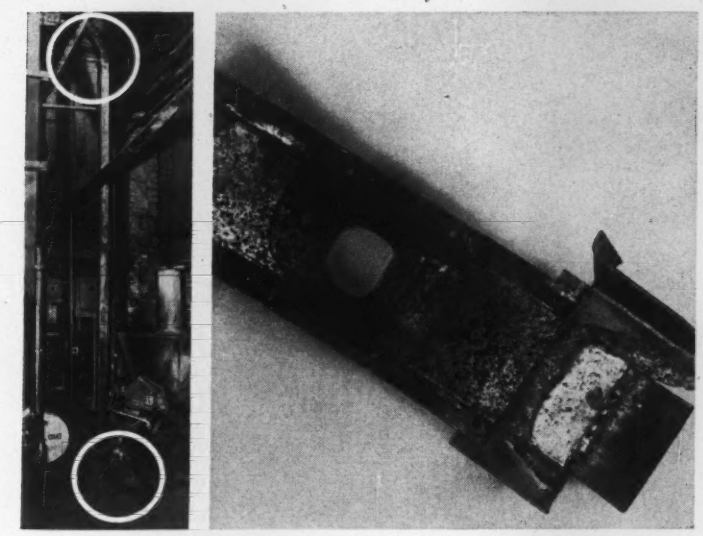
Reviews available information on the tendency of titanium to ignite under impact when exposed to strong oxidizers of the type used in rocket and missile propulsion systems.

Cryogenic materials CRYOGENIC MATERIALS DATA HANDBOOK. *T. F. Durham and others. Cryogenics Engineering Laboratory, National Bureau of Standards. Sept '61. 555 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $7 (PB 171 809)*

Compilation of 22 properties of metals, alloys and nonmetallic materials at cryogenic temperatures. Covers aluminum, cobalt, copper, iron, nickel, titanium, carbides, beryllium, molybdenum, and such nonmetallics as ice, Mylar and TFE. A summary of testing procedures is included.

Thermal properties MEASUREMENT OF THE THERMAL PROPERTIES OF METALS AT ELEVATED TEMPERATURES. *R. L. Rudkin and others. U. S. Naval Radiological Defense Laboratory. May '60. 24 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 75¢ (PB 171 185)*

Discusses an investigation of the thermal properties of tungsten to evaluate its potential use in the construction of rocket nozzles and combustion chambers, and at the surfaces of nose cones and re-entry vehicles.



175° F. sand, being blown to storage, regularly wore through special abrasion-resistant alloy steel wear plates at duct elbows in only 2 months.

Abrasive sand finally gnawed through ADIPRENE® urethane rubber liner in elbows—but it took 6 months.

Foundry finds ADIPRENE® outwears steel 3 to 1

This interesting application shows dramatically how tough ADIPRENE urethane rubber really is. And designers are finding that this outstanding abrasion resistance . . . plus excellent load bearing capacity and low temperature resistance . . . is the solution to many design problems.

For example, industrial wheels made of ADIPRENE are outlasting those made of ordinary rubber 5 to 1. A leading auto manufacturer is using ADIPRENE for longer lasting ball joint seals. Manufacturers in both civilian and defense industries use ADIPRENE for impact, shock and abrasion resistant mounts, bumpers, bushings, suspension straps. A metalworking company is employing ADIPRENE as a female stamping die . . . finds that it survives 50,000 impacts as compared to only 400 for ordinary rubber. From "potting" to pulleys . . . from shoe heels to shock resistant grinding wheels . . . ADIPRENE's unique set of properties can help you design better, longer lasting new products. For more information about ADIPRENE write E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MDE-11, Wilmington 98, Delaware.

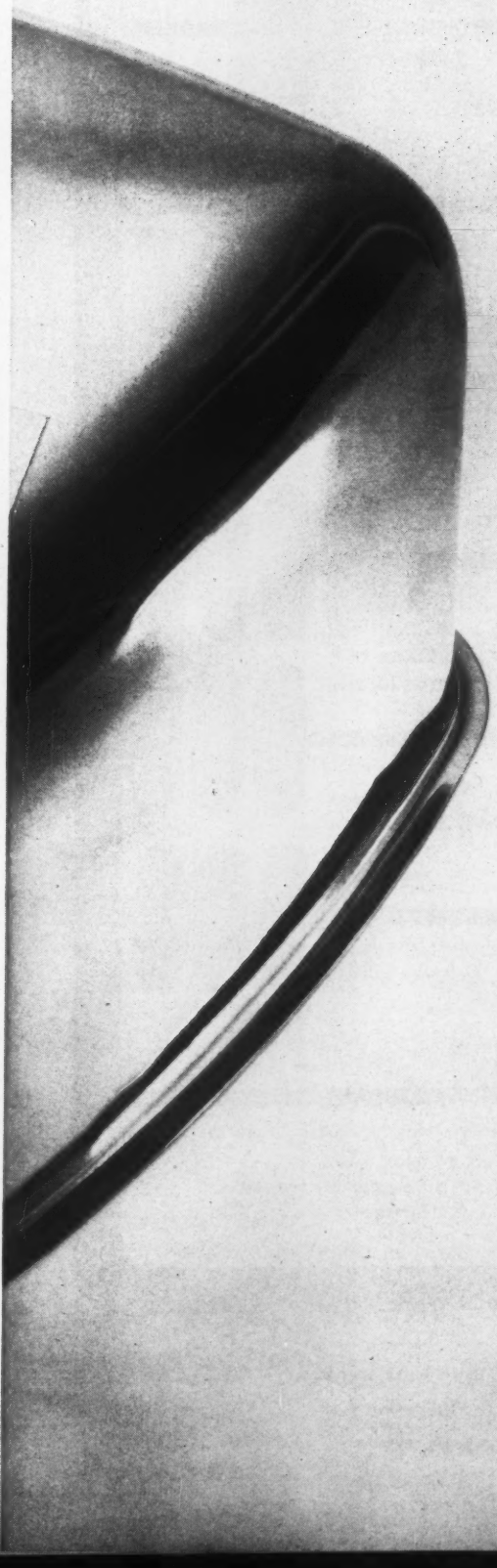
DU PONT
REG. U. S. PAT. OFF.

ADIPRENE®
URETHANE RUBBER

Better Things for Better Living . . . *through Chemistry*

For more information, turn to Reader Service card, circle No. 387

Chrome
Plated
Steel



This mark tells you a product is made of modern, dependable Steel.

How a "specially tailored" strip reduces production rejects almost 25% for Kromex

Kromex, Inc., Cleveland, Ohio, turns out a complete line of pantry ware, but they were having trouble with a square, mirror-finish chromium-plated cake cover that was made with a single deep draw. Rejection rate was a stunning 25%. They first tried a No. 3 finish for this application, but because of the very deep draw and the dense and smooth surface, satisfactory lubrication was near impossible. The result: Excessive draw marks and breakage. A regular No. 2 finish was then tried. The draw was successful. But buffing and finishing costs were prohibitive for this application.

American Steel and Wire salesmen conferred with our Metallurgical Department and suggested a specially tailored No. 3 finish. Reject rate dropped to less than 1% because the special surface was able to hold lubricant evenly, but smooth enough to draw and plate flawlessly.

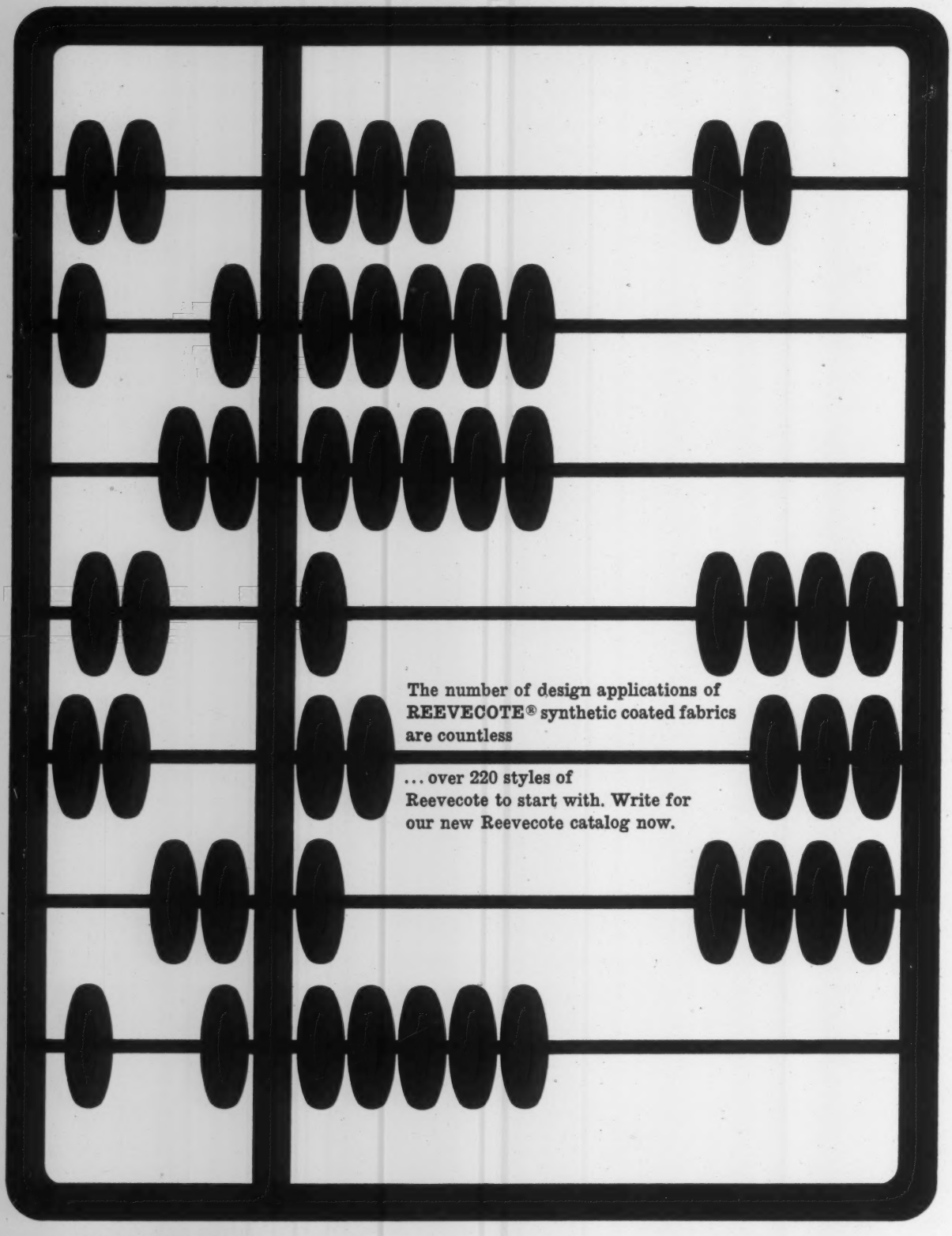
Kromex is one more example of how strip, *tailored to end use,* works to produce a better product at lower cost. When you buy strip, you're buying a specific chemistry, temper, dimension, edge and finish that is consistently uniform within the coil or from coil to coil. Certain of your processing steps may actually be eliminated by using cold rolled strip, produced in our mills, and tailor-made for your specific end use.

Take a hard look at your production line and let our salesmen and metallurgical people look too. There's a good chance you can improve quality and cut production costs at the same time with *tailored-to-the-job* cold rolled strip from American Steel and Wire. American Steel and Wire Division, Rockefeller Bldg., Cleveland 13, Ohio. *USS and American are registered trademarks.*

USS American Steel and Wire Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal & Iron Division, Fairfield, Alabama, Southern Distributors
United States Steel Export Company, Distributors Abroad

For more information, circle No. 474

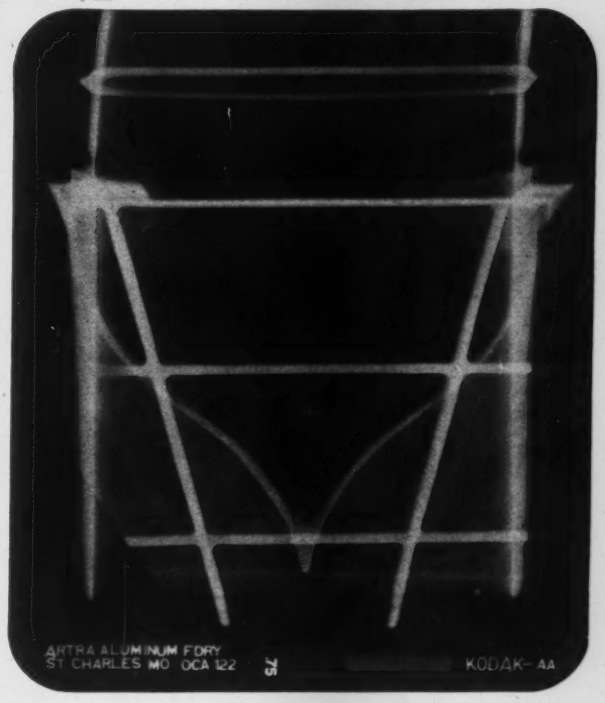

The number of design applications of
REEVECOTE® synthetic coated fabrics
are countless
... over 220 styles of
Reevecote to start with. Write for
our new Reevecote catalog now.

REEVES
VULCAN

Reeves Brothers, Inc., 1071 Avenue of the Americas, New York 18, New York

For more information, turn to Reader Service card, circle No. 479

To keep cool at a couple of "machs"



Photograph and radiograph of aircraft refrigeration duct cast of magnesium AZ91.

At jet speeds a problem is to keep the pilot cool. Artra Aluminum contributes this magnesium casting for a refrigeration duct, and uses radiography to assure that it is sound and dependable.

Without proper cooling in the cockpit, today's supersonic pilots would cook. Refrigeration is a "must."

Along with other components, Artra Aluminum Foundry of St. Charles, Missouri, provides this AZ91 magnesium casting for the pilot's cooling system. It is ultralight, and ultrastrong. And radiography is used to make certain that there are no flaws.

Artra has earned an outstanding reputation for fine work with materials difficult to cast. And they give full credit to the way radiography helps them to evolve casting methods that greatly reduce rejections and thus makes sure that only quality work is delivered.

Foundries, large and small, find that radiography quickly becomes a valuable asset in their operations. It can work for you, too. You can learn how by getting in touch with an X-ray dealer or writing us to have a Kodak Technical Representative call.

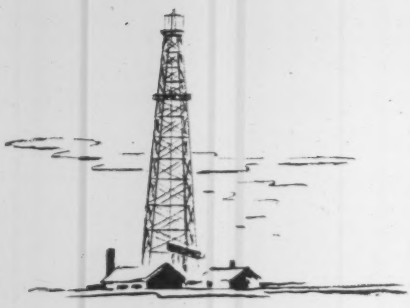
Now . . . Ready Pack
in ROLLS and SHEETS
Kodak Industrial X-ray Film,
Types AA and M in 200-ft. rolls
(16mm, 35mm, 70mm) and sheets
(8 x 10, 10 x 12, 11 x 14, 14 x 17).

- No darkroom loading—film sealed in a lighttight envelope.
- Just place Ready Pack in position and expose.
- Film protected from dust, dirt, light, and moisture.
- In the darkroom—remove film from envelope and process.

EASTMAN KODAK COMPANY
X-ray Sales Division • Rochester 4, N.Y.

Kodak

For more information, turn to Reader Service card, circle No. 347



MUD was rough on oil drill nozzles!

Abrasion was causing hardened steel and even special alloy mud nozzles to wear out too fast. A metal exceptionally resistant to the scouring action of drilling mud was needed.

V-R CARBIDE solves the problem

Nozzles made of V-R carbide now far exceed the life of previously used metals. This is an example of creative engineering at Vascoloy-Ramet where metals are developed to meet physical specifications. Characteristics such as abrasion and corrosion resistance, dimensional stability, high density and strength are properties that are produced in varying degrees in V-R sintered or alloyed metals. Send us your specifications for your custom metal needs.

V-R

CREATING THE METALS THAT SHAPE THE FUTURE

VASCOLOY-RAMET

856 MARKET STREET • WAUKEGAN, ILLINOIS

A-827

For more information, turn to Reader Service card, circle No. 392

ALMOST ANYTHING CAN BE IMPROVED... IN PLASTICS MOLDED BY GENERAL AMERICAN

John T. Riddell Inc. wanted safer one-piece helmets for pro football. General American helped provide the answer.

Now every player on every professional football team can enjoy a new measure of protection against injuries. General American worked with the John T. Riddell Co., engineered a "collapsible" mold which made possible the production of one-piece plastic helmets to rigid specifications. These helmets have been proved in gruelling play (and even more gruelling laboratory tests.) The man at the bottom of a pile-up or at the business end of a cleat is safer than ever before.

Resourceful solutions like this are not at all exceptional at General American's Plastics Division. Our engineers and plastics specialists are backed by the largest, most varied molding facilities in the world: compression presses to 2000 tons . . . injection presses to 300 ounces . . . large extruding and vacuum-forming machines unmatched anywhere.

If you'd like to move profitably into plastics, you'll certainly find it pays to plan with General American.

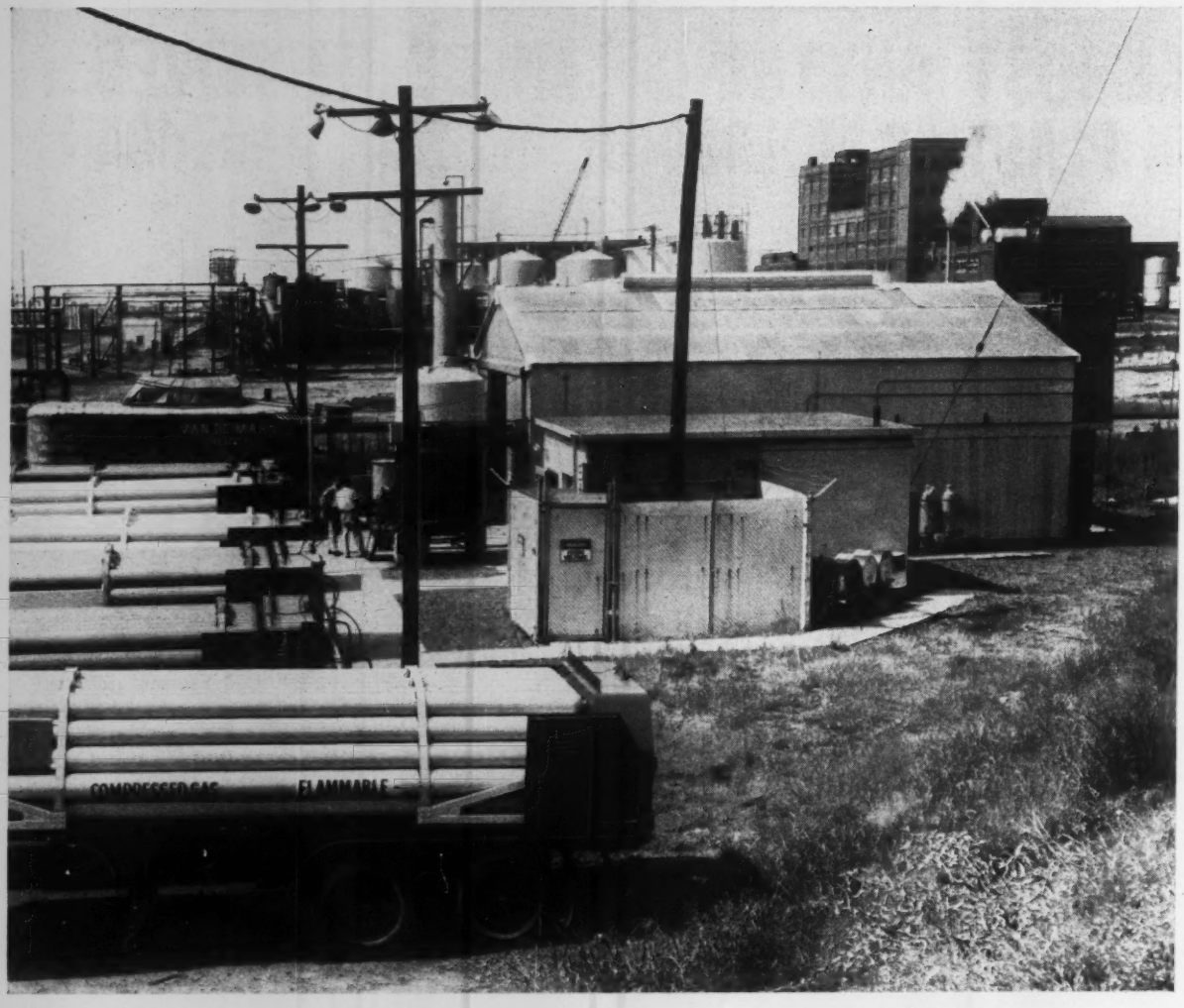
PLASTICS DIVISION GENERAL AMERICAN TRADE MARK

Plastics Division

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South La Salle Street • Chicago 3, Illinois • Offices in principal cities

For more information, turn to Reader Service card, circle No. 423



How only 5 men and a small plant produce 15 million cubic feet of pure hydrogen a month

Nickel stainless steel permits unique plant design for new low-cost cryogenic process

What's so unusual about this Van de Mark hydrogen purification plant in Linden, New Jersey?

First, at a low capital investment of about $200,000, it has handled the purification of a neighboring refinery's off-gas hydrogen for 2½ years with no "downtime" and minimum maintenance. Only 5 men are needed to keep the plant going.

Second, the plant produces low-cost, pure hydrogen through a cryogenic process. Impurities are removed through fractional condensation when the hydrogen is cooled to −320 F. At this point, most other gases become liquid—yet the hydrogen remains a gas—permitting the liquids to be removed by means of absorbent beds and molecular sieves.

AISI Type 304 Nickel stainless steel was selected as the most practical and economical material for the absorbers, molecular sieves, and interconnecting piping. Strong and tough even far below −320 F, these Nickel stainless steel components are sealed away out of view . . . and away from the maintenance that simply isn't needed.

Type 304 is just one of the Nickel-containing steels that can withstand the damaging effects of super-cold . . . and at the same time offer the strength, toughness, and corrosion resistance that protects the purity of many a process stream. Ready availability plus fabricability are an added advantage.

If your operations involve low temperatures (even −454 F) get the facts on how the Nickel-containing steels can go to work for you at practical cost. Write to Inco describing your metals requirements.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

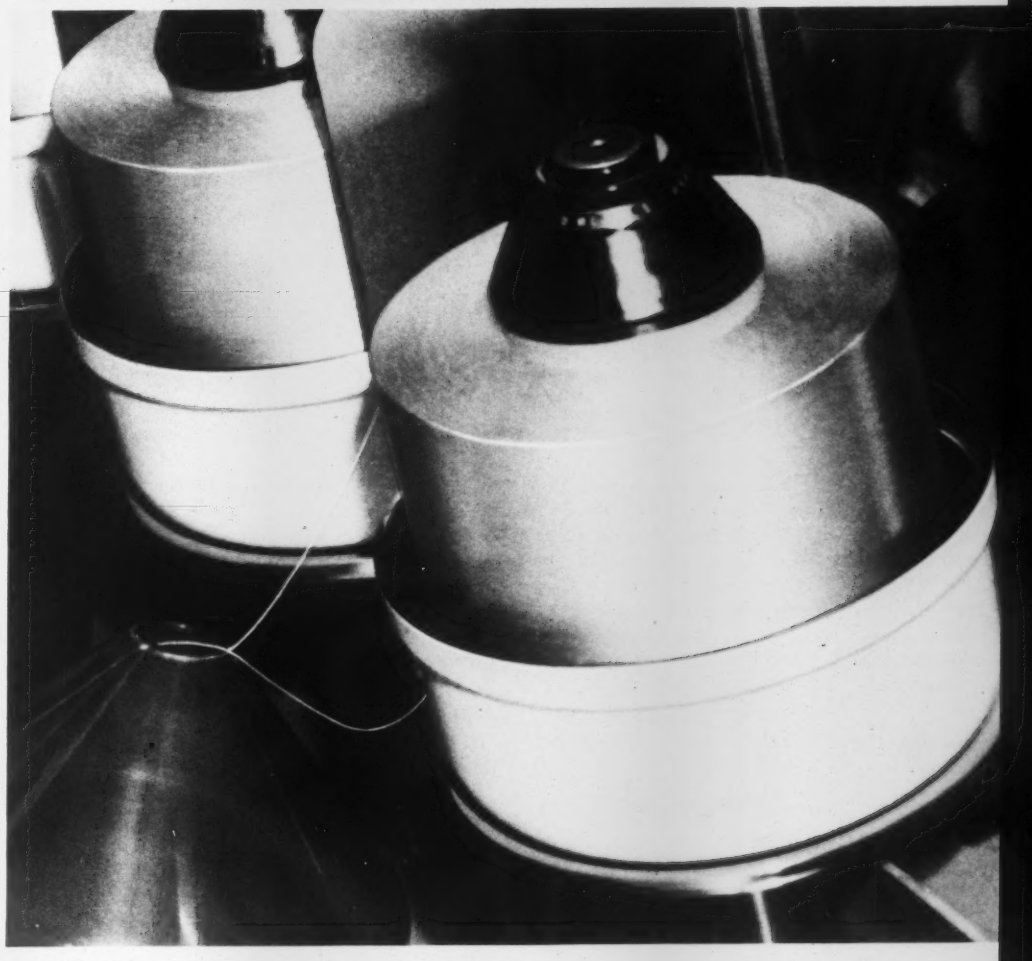
MAKES STEELS PERFORM BETTER LONGER

For more information, circle No. 460 ➤

working with

Du Pont Delrin®

one of Du Pont's versatile engineering materials



New textile supply buckets of DELRIN® last longer... cost less

Large (10 in. diameter, 1¼ lbs.) buckets economically injection-molded of Du Pont DELRIN acetal resin provide Leesona Corporation, Providence, R. I., with a rugged, long-wearing part for their heavy-duty textile machinery.

Evenly wound packages of filament yarn sit within the buckets of DELRIN (shown above) on a multi-spindle Twister-Coner machine. This machine transfers the yarn from the evenly wound spools to cones at a rate of 340 yards per minute.

The bowl-shaped buckets (molded by Crystal Thermoplastics, Inc., Pawtucket, R. I.) are stationary and thus are subject to abrasion and static build-up by friction of the moving yarn. DELRIN resists both—in fact, outwears phenolic resins previously used—and, in addition, DELRIN maintains its dimensional stability in dry or humid environment.

DU PONT

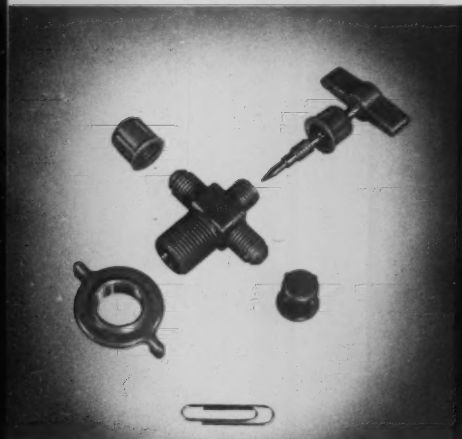
REG U.S. PAT. OFF.

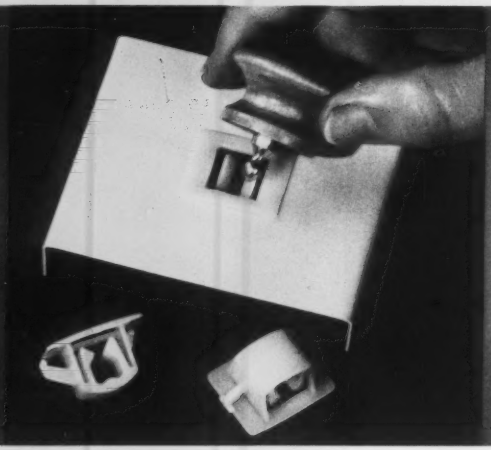
BETTER THINGS FOR BETTER LIVING THROUGH CHEMISTRY

working with

Du Pont Delrin®

one of Du Pont's versatile engineering materials





CAN TAP VALVE for use with packaged refrigerant containers is molded entirely of DELRIN except for piercing needle. Molded-in threads are strong and clean; caps fit tightly. Parts molded of Du Pont DELRIN do not corrode and maintain their dimensions under a wide range of temperatures and humidity. (Molded by Industrial Plastic Molders, Inc., for Watsco, Inc., both of Hialeah, Florida.)

CABINET CATCHES molded of DELRIN take advantage of the resilient, spring-like properties of this resin to permit easy installation of the catch and to hold the steel strike. Abrasion and fatigue resistance of DELRIN allow long life under repeated cyclic stressing of the retaining fingers. Its natural lubricity permits steel strike to move smoothly. (Made by Amerock Corp., Rockford, Ill.)

LAWN SPRINKLERS molded of toug Du Pont DELRIN resist abrasion fro sand and silt. DELRIN offers excellen resistance to corrosion and "lime-up" trouble-free service, excellent threa strength. And a choice of colors is mad possible by the integral colors of DELRI acetal resin. (Molded by Lee Deane Pro ducts, Inc., for Plasmet Engineering Co both of Santa Fe Springs, California.)

DELRIN has strength and toughness

to function reliably under rugged usage. Parts molded of Du Pont DELRIN acetal resin retain a high degree of their mechanical properties under severe environmental conditions, such as high temperatures, moisture, solvents and many corrosive chemicals.

Many designers are taking advantage of the wide range of unique properties of DELRIN, and the substantial cost economies in manufacture and assembly. Why not investigate the possibilities of DELRIN for your product? Mail the coupon below for more information.

POLYCHEMICALS DEPARTMENT

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.)
Department 4 Room 2507-D
Nemours Building, Wilmington 98, Delaware

I am interested in evaluating DELRIN for the following use:

_____

*Name*_____

*Company*_____ *Position*_____

*Street*_____

*City*_____ *Zone*____ *State*_____

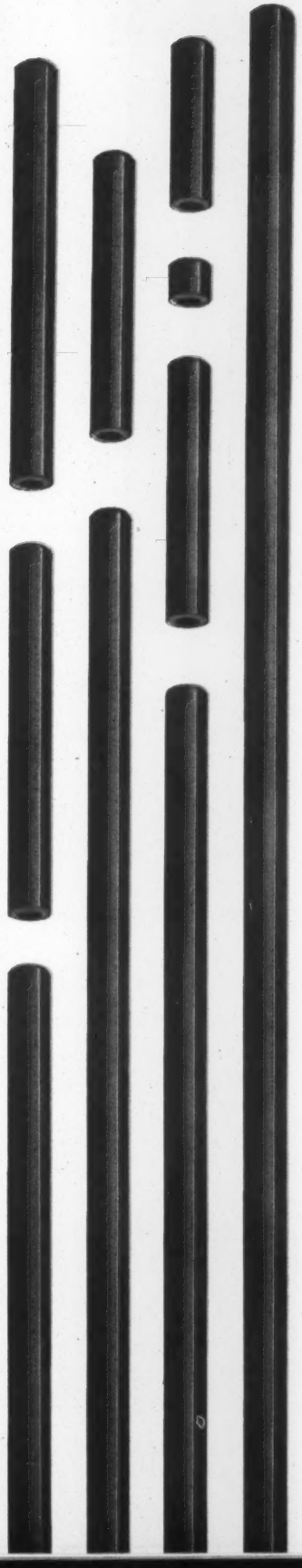
In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

A

DELRIN® *acetal resins*

one of Du Pont's versatile engineering materials

Alathon® · Zytel® · Lucite®



How ASARCON Bronze cut to length saves you money

Each time your machinist is left with a costly scrap end from a cast bronze bar, the dollar economy of cut-to-length, continuous-cast Asarcon Bronze is re-emphasized.

When you use 13″ cast bars, you have a remnant problem. For example, a 1″ remnant from such a bar is over 7.6% loss, a 1½″ piece is over 11.5% loss, a 2″ scrap is over 15.3% loss. And the cost of the finished parts *must* include the purchase price of these remnants.

However, you can buy continuous-cast Asarcon Bronze from stock in lengths up to 105″ and cut off short pieces as required, or you can buy cut-to-length pieces to meet each job's specifications. You can eliminate both inventory costs and waste of expensive metal.

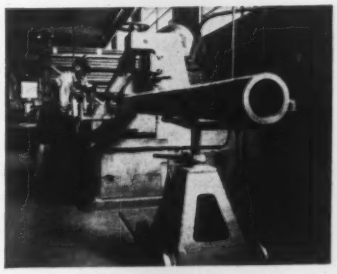
In addition to savings on end scrap, Asarcon Bronze bars provide these minimum clean-up allowances: $\frac{1}{32}$″ on diameters up to 4″; $\frac{1}{16}$″ on diameters from 4″ to 5″; $\frac{3}{32}$″ on diameters from 5″ to 9″.

Other important advantages of Asarcon cut-to-length bronze:

- Available from stock in 263 sizes, solids and tubes, from ½″ to 9″ in diameter.
- Superior metallurgical characteristics — no blow-holes, pits, shrinks, hard or soft spots.
- Better physical properties due to higher tensile, yield and impact strengths; greater resistance to metal fatigue.

For further information, call or write your Asarcon distributor or write: Continuous-Cast Dept., American Smelting and Refining Company, Perth Amboy, N. J., or Whiting, Ind.

ASARCO



Cutting stock length of 9″ O.D. Asarcon Bronze tubing to exact length specified by customer.

ASARCON® BRONZE

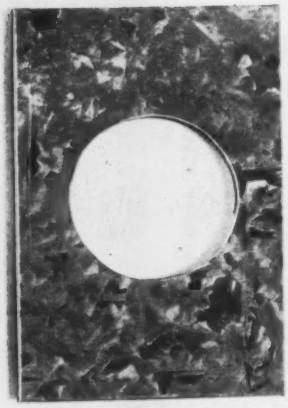
For more information, turn to Reader Service card, circle No. 385

SOFTITE BY WHEELING

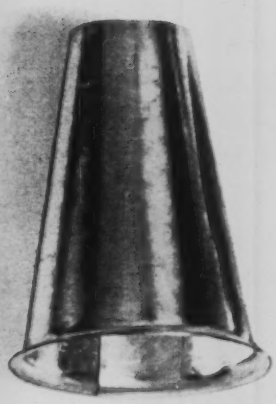
...bend it

...hem it

...scribe it



...punch it

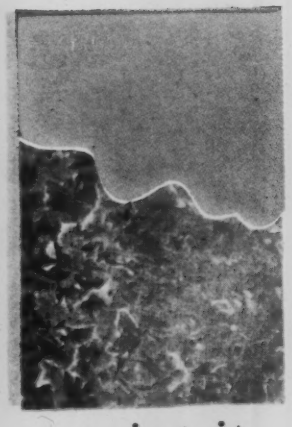


...form it

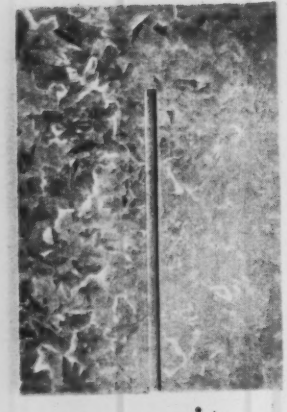
...notch it

...lock it

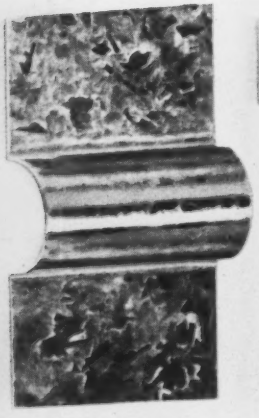
...snip it



...paint it

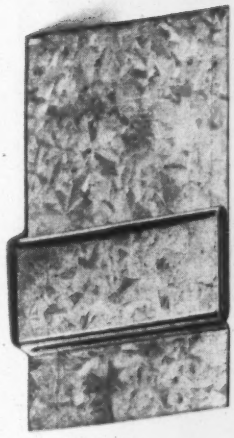


...saw it

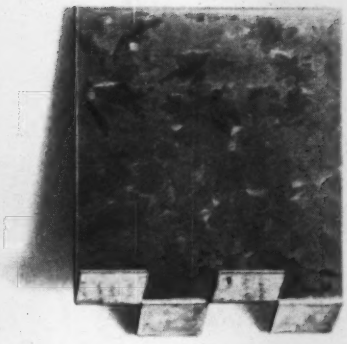


...stamp it

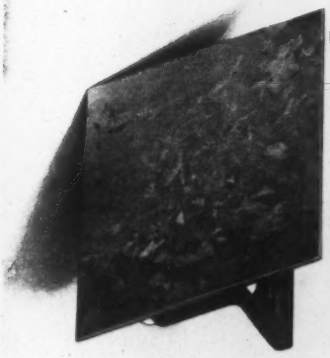
...shear it



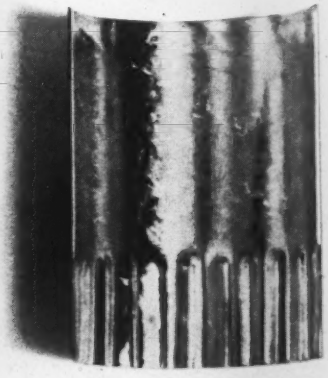
...seam it



...dovetail it



...weld it



...crimp it

...slit it

...draw it

OUR CHALLENGE STANDS!

"Anything that can be made of steel sheets can be made of Wheeling SOFTITE® galvanized steel sheets!"

WHEELING STEEL CORPORATION • IT'S WHEELING STEEL!

District Sales Offices located at Atlanta, Buffalo, Chicago, Cincinnati, Cleveland, Detroit, Houston, New York, Philadelphia, St. Louis, San Francisco, Wheeling

Steel

For more information, circle No. 420

Fluorine and Fluorides Causing Corrosion?

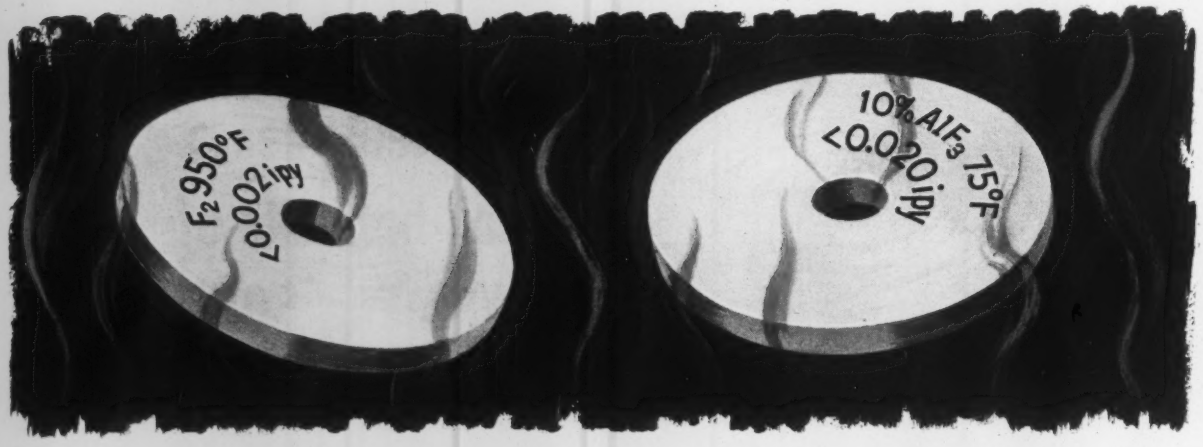
...Test **HAYNES** Alloys

Ability to withstand the "bite" of fluorine and fluorides is a quality possessed by few metals. HASTELLOY alloy C has this ability.

Alloy C is resistant to fluorine gas as hot as 950 deg. F, and it is so impervious to HF gas it can be utilized in the production of hydrofluoric acid. The remarkably low penetration rates shown on the test samples in the illustration indicate the extraordinary resistance of alloy C to this family of corrodents.

HASTELLOY alloy C is one of 9 HAYNES corrosion-resistant alloys developed over a 30-year span of intensive research on corrosion problems and metals that resist them. You can capitalize on the results of this 30-year research program.

Send for test samples. Write us a letter outlining your corrosion problem. We will send you free test samples of the alloy best suited to solve it. Address your letter to Haynes Stellite Company, 270 Park Avenue, New York 17, N. Y.



HAYNES
ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

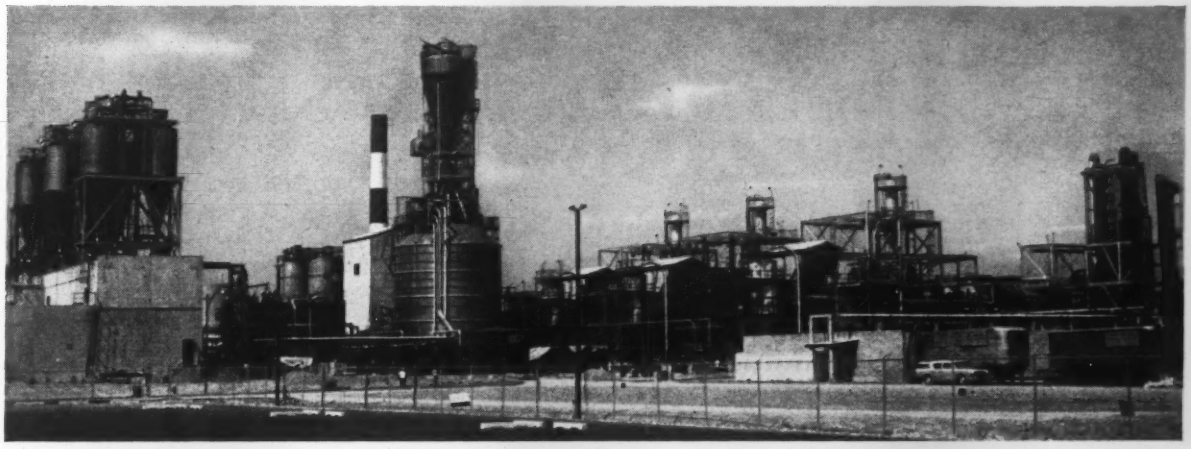
UNION CARBIDE

"Haynes," "Hastelloy," and "Union Carbide" are registered trade marks of Union Carbide Corporation.

For more information, turn to Reader Service card, circle No. 454

AVISUN

announces world's biggest polypropylene plant now in production



100 million lb/yr capacity assures ample supplies of polypropylene for the fast-growing number of users

This giant new plant at New Castle, Del., establishes AviSun more firmly than ever as the industry's leading polypropylene supplier. It incorporates the most advanced manufacturing techniques—continuous processing—meticulous quality control—to produce polypropylene polymers of top quality and dependable uniformity. The polymers include a broad new range of impact grades, pipe grades and other specialty resins for fiber—and wrapping film in varying mil thicknesses.

From this great new facility will come the materials for strong, light, low-cost products of every description to meet the needs of home and industry.

And AviSun stands ready with technical assistance. Fully equipped Customer Service laboratories—specialists with a broad and diversified background of experience in application problems—are at your service.

So plan now to explore the advantages of manufacturing or packaging with AviSun polypropylene. Complete technical data on AviSun polymer and film will be sent on request.

AVISUN CORPORATION
Executive Offices
1345 Chestnut St., Philadelphia 7, Pa.
In Canada-Courtaulds Plastics Canada, Ltd.

AVISUN*

*Trademark of AviSun Corp.

For more information, turn to Reader Service card, circle No. 353

Another First from AVISUN...

OLEFORM*

a new, unusually low-cost thermoplastic now available for experimental testing...

Featuring—Unusual toughness and rigidity • High heat resistance • Excellent chemical resistance • Low moisture absorption • Good electrical insulation qualities

In rigidity and toughness Oleform compares favorably with thermosetting materials in many applications. And its improved creep resistance and mold shrinkage factors excel those of polyolefins. It can be injection molded satisfactorily, thus permitting faster mold cycles than for compression molded thermosetting materials. Its electrical insulation properties compare well with those of thermosets. And unlike thermosets, its molding scrap is reuseable.

Oleform is available in a blue-gray molding grade in *experimental* quantities. AviSun technical specialists stand ready to assist you in any developmental work. For full details, fill in and mail coupon today.

AVISUN.*

*Trademark of AviSun Corp.

AVISUN CORPORATION, Dept. 649
1345 Chestnut St., Philadelphia 7, Pa.

I am interested in Oleform. Send full data available.

Name_____ Title_____

Company_____

Address_____

_____

In Canada: *Courtaulds Plastics Canada, Ltd.*

COMPARISON

Properties	ASTM	OLEFORM	Acetal	Nylon 66	Wood Flour Filled Phenolic
Mechanical[a]					
Tensile Yield Strength[b], 10^3 psi	D638	4.5	9.8	8.5-9	7.5
Elongation at Yield[b], %	D638	6	10	60	1
Tensile Modulus[c], 10^5 psi	D638	2.9	3.75	1.75	10
Flexural Modulus[d], 10^5 psi	D790	5.5	4.1	1.75	10
Izod Impact Strength, ft-lb/in notch	D256	0.9	1.4	2.0	0.3
Physical					
Specific Gravity	D792	1.24	1.43	1.14	1.45
Heat Distortion Temp., °F	D648				
at 66 psi		295	338	360-390	300
at 264 psi		205	212	150-170	275
Water absorption (24 hr.) %	D570	0.02	0.12	1.5	0.6
Lin. Coef. of Ther. Exp., 10-5 in/in/°C	D696	3.8	8.1	10	3.8
Chemical Resistance					
Acids		Excellent	Attacked	Attacked	Good
Bases		Excellent	Attacked	Excellent	Attacked
Solvents		Good	Excellent	Good	Good
COST					
Cents/lb		36	65	98	22
Cents/cu in		1.5	3.3	4.0	1.2

[a] Injection molded specimens at room temperature
[b] Crosshead speed 1/min
[c] Crosshead speed 0.2/min
[d] Crosshead speed 0.05/min

For more information, turn to Reader Service card, circle No. 354

• Easy fabrication • Easy welding and joining • Light weight • Low cost • High heat resistance • High chemical resistance • Low friction loss • Approved for potable water use by National Sanitation Foundation

In an important advance stemming from extensive research, AviSun introduces the first high molecular weight polypropylene pipe grade resin combining low cost with excellent properties. It has been broadly tested with highly satisfactory results. AviSun pipe grade resin can be processed in most conventional plastic extruders—at rates equal to or greater than that of linear polyethylene. Its high per-pound yield makes it one of the most economical plastics.

Because of the attractive properties, pipe from this resin should yield optimum performance in such applications as: salt water disposal lines; gas gathering and distribution systems; crude oil flow lines; conduit; municipal water systems; process lines for organic and inorganic chemicals; automotive and aircraft tubing, and many others. For more data on AviSun polypropylene 1051 pipe grade resin, fill in coupon.

AVISUN*

*Trade mark of AviSun Corp.

AviSun Corporation, Dept. 613
1345 Chestnut St., Philadelphia, Pa.

Send me complete data on new 1051 pipe grade resin.

Name_____ Title_____

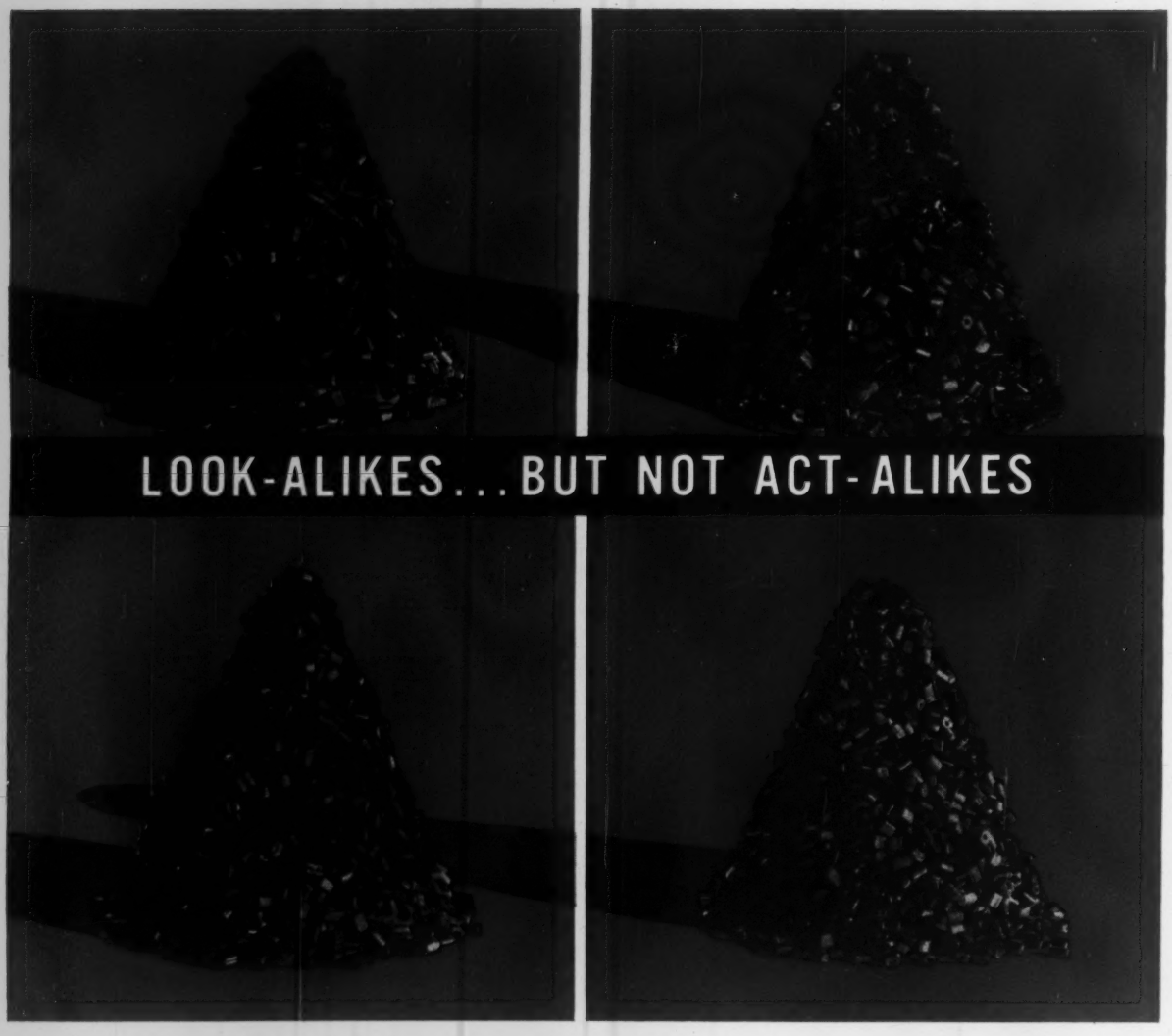
Company_____

Address_____

_____

In Canada: *Courtaulds Plastics Canada, Ltd.*

For more information, turn to Reader Service card, circle No. 355



AVISUN announces four new impact grades of polypropylene

Here, for the first time, are new impact grades of polypropylene—all possessing a translucent white resin color—with flow rates suitable not only for injection molding, but also for sheet extrusion, vacuum forming and blow molding. All four retain desirable properties characteristic of general purpose polypropylene—lightness, low cost, high heat and chemical resistance. *But each grade offers a step-up in impact strength at room temperatures.* Equally important, most of this strength is retained at lower temperatures—in the case of High Impact Grade 3210, as low as 10°F.

AviSun technical specialists can help if you plan to use a new AviSun impact grade of polypropylene for *your* product. For full technical data or counsel, write to us.

SPECIAL PROPERTIES

Property	Impact Grade 3116	Impact Grade 3216	High Impact Grade 3211	High Impact Grade 3210
Izod Impact Notched—ft-lb/in Unnotched	1.5 over 16	2.0 over 16	10 over 16	15 over 16
Flow rate—gm/10 min (nominal)	5.0	5.0	0.7	0.5
Type of molding	injection	injection	sheet extrusion vacuum forming	blow

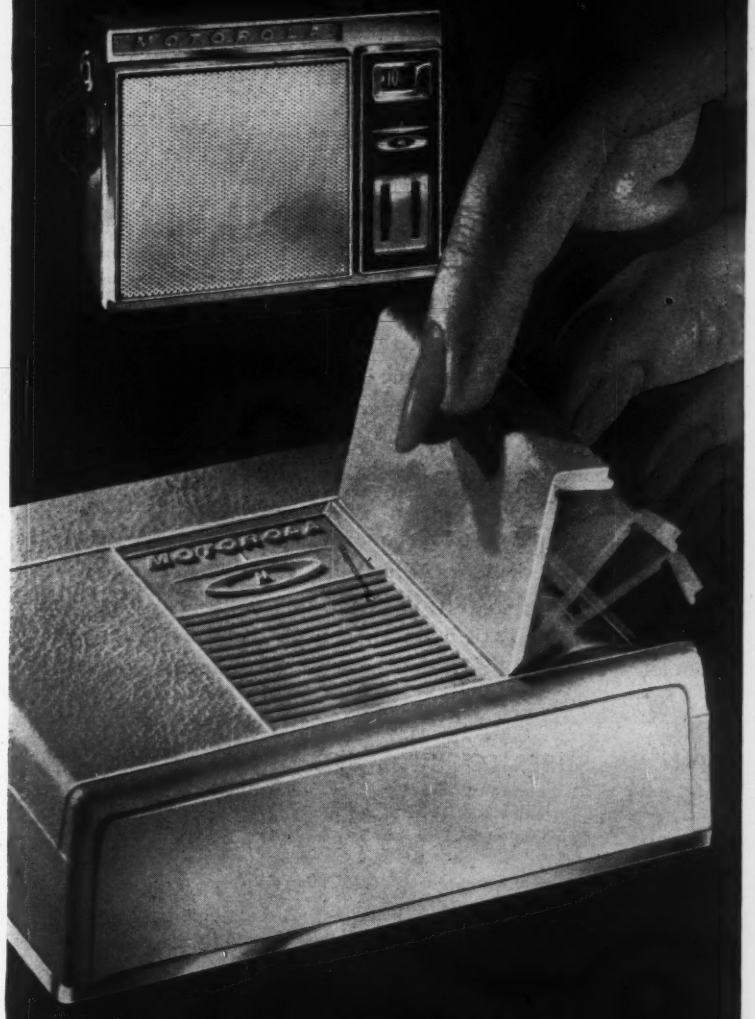
AVISUN CORPORATION
Dept. 612
1345 Chestnut St.
Philadelphia 7, Pa.
In Canada: *Courtaulds Plastics Canada, Ltd.*

AVISUN*

*Trademark of AviSun Corp.

For more information, turn to Reader Service card, circle No. 356

Flex it a million times...an



Speaker vents spaced 0.020", molded-in snaps, and thin-section self-hinge on battery door show the molding versatility of AviSun injection grade polypropylene. Custom molded for Motorola by Sinko Manufacturing and Tool Co., Chicago 31, Illinois.

AVISUN

polypropylene self-hinge *won't break!*

Motorola chose AviSun polypropylene for the cases of their transistor radios for these good reasons:

UNIQUE FLEXIBILITY. Self-hinge characteristic is new in the plastics field . . . can be used to cut costs, speed assembly, improve designs on a wide range of cases, boxes, and receptacles.

HEAT RESISTANCE. Polypropylene will not soften or lose strength, even at temperatures close to 220°F.

TOUGHNESS. Has the resiliency to absorb dropping and rough handling without chipping, cracking, or breaking.

ECONOMY. Polypropylene, lightest of all plastics, gives high yield per pound. Takes texture, detail and speaker vents beautifully.

The same advantages that make polypropylene the choice for transistor radio cases can benefit you in *your* product. Call on AviSun for complete data on resin grades —and for expert technical assistance.

AVISUN*

*TRADEMARK OF AVISUN CORP.

Mail coupon for technical information

AVISUN CORPORATION
Dept. 595 1345 Chestnut St.
Philadelphia 7, Pa.

Send me Booklet AP-601 giving full technical information on AviSun Polypropylene.

NAME_____
(Please Print)

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

In Canada: *Courtaulds Plastics Canada, Ltd.*

For more information, turn to Reader Service card, circle No. 357

SOLVE FASTENER PROBLEMS CAUSED BY SHOCK OR VIBRATION...

SIMPLIFY ASSEMBLY

with Republic NYLOK® Bolts and Nuts

Applications are unlimited for rugged, self-locking Republic NYLOK® Bolts and Nuts. They lock tight—seated or not—to simplify assembly, solve a wide range of design and engineering problems caused by shock or vibration.

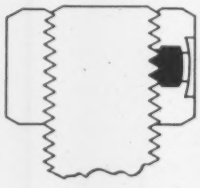
Single-unit NYLOK Bolts and Nuts are easy to apply manually or automatically, can be used over and over. NYLOK Nuts are double-chamfered to permit automatic feeds at top production speeds, save time and money.

Check your product for applications where NYLOK's positive holding power can do the job better, save you money. For sizes, prices, and application data on NYLOK Bolts and Nuts, contact your Republic Dealer, or send the coupon.

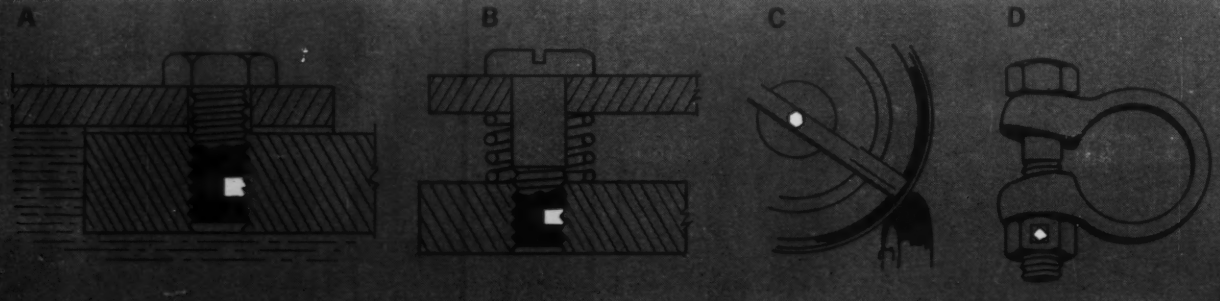
Steel Strong, Modern, Dependable

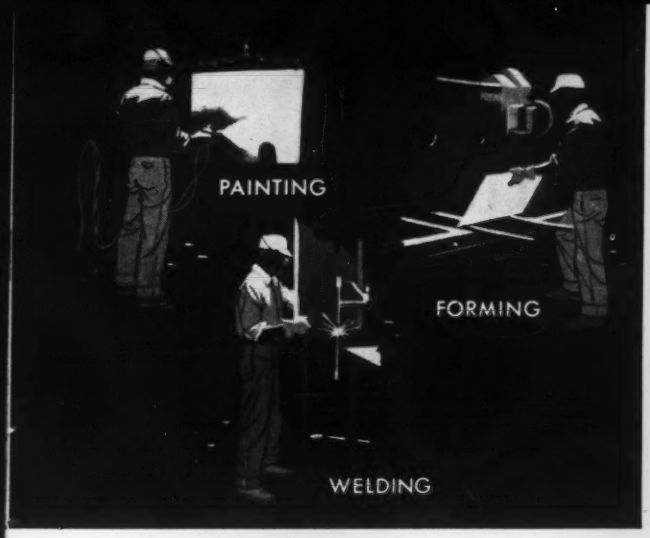
NYLOK'S SUPER-LOCKING SECRET

is its nylon plug, firmly staked into one of the faces of the cold forged hex nut, or into the body of the bolt. The plug has a plastic memory—or a natural tendency to recover its original shape and "grow" into opposite mating threads. This forces tight metal-to-metal contact for a vibration-proof lock that can't shake loose.

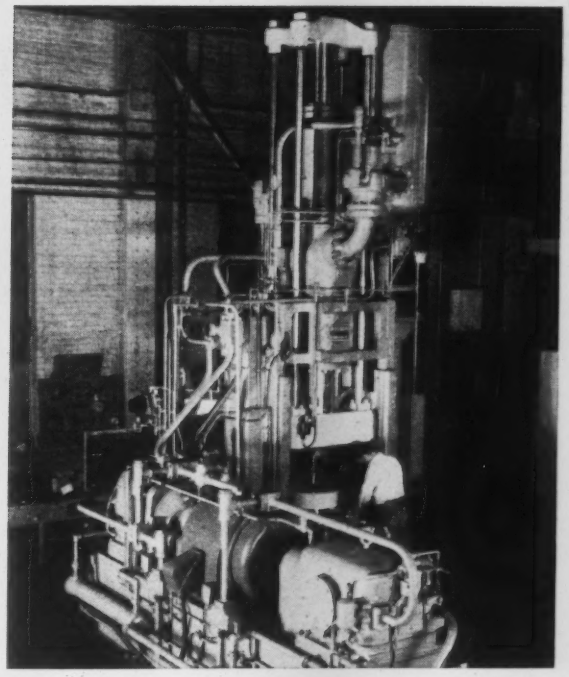


Typical NYLOK applications: (a) NYLOK Bolt as a fastener-sealer to effectively block fluid escape along thread path; (b) NYLOK Bolt used to solve tension or vibration fastening problems; (c) NYLOK Nut used to secure lawnmower rotor blade under severe vibration conditions; (d) NYLOK Nut employed to lock tight against pressure of a spring-clamp.





FROM DEVELOPMENT THROUGH FINISHED PRODUCT Republic's Berger Division can help you cut costs on sheet metal fabrication. Contract manufacturing specialists for more than five decades, Berger has a well rounded stock of tools and dies; a complete machine shop; modern, automated production lines for shearing, punching, forming, welding, Bonderizing, painting, and packaging. Berger will handle your complete job or any phase of it. Send the coupon for complete information.



STUBBORN RESISTANCE TO FATIGUE is one important reason builders of machine tools prefer Republic ELECTRUNITE® Hydraulic Fluid Line Tubing. Consistent uniformity of concentricity, temper and weld strength make ELECTRUNITE better able to withstand the vibrations of rapid multiple cycling. Uniformly ductile for easy bending.

Pictured is a 500-ton hydraulic press built by Birdsboro Foundry and Machine Co., Birdsboro, Pa. ELECTRUNITE is used extensively in this unit. Send the coupon for more data on Republic ELECTRUNITE Fluid Line Tubing.

SAVE MONEY ON TOUGH-TO-MAKE PARTS. Elliott Co., Jeannette, Pa., does it by producing rotor buckets for mechanical drive turbines from Republic Stainless Steel Special Sections.

User benefits include: simplified machining, corrosion and abrasion resistance, greater strength and hardness, smooth surfaces that reduce or eliminate finishing operations. Republic Special Sections are available in a wide range of sizes and contours—carbon, alloy, stainless steels, and titanium. Send coupon.

REPUBLIC STEEL

REPUBLIC HAS THE FEEL FOR MODERN STEEL

For more information, circle No. 485

REPUBLIC STEEL CORPORATION
DEPT. ME-2041-B
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Send more information on:

- ☐ NYLOK Nuts and Bolts
- ☐ ELECTRUNITE® Hydraulic Line Tubing
- ☐ Contract Facilities
- ☐ Special Sections

Name_____ Title_____

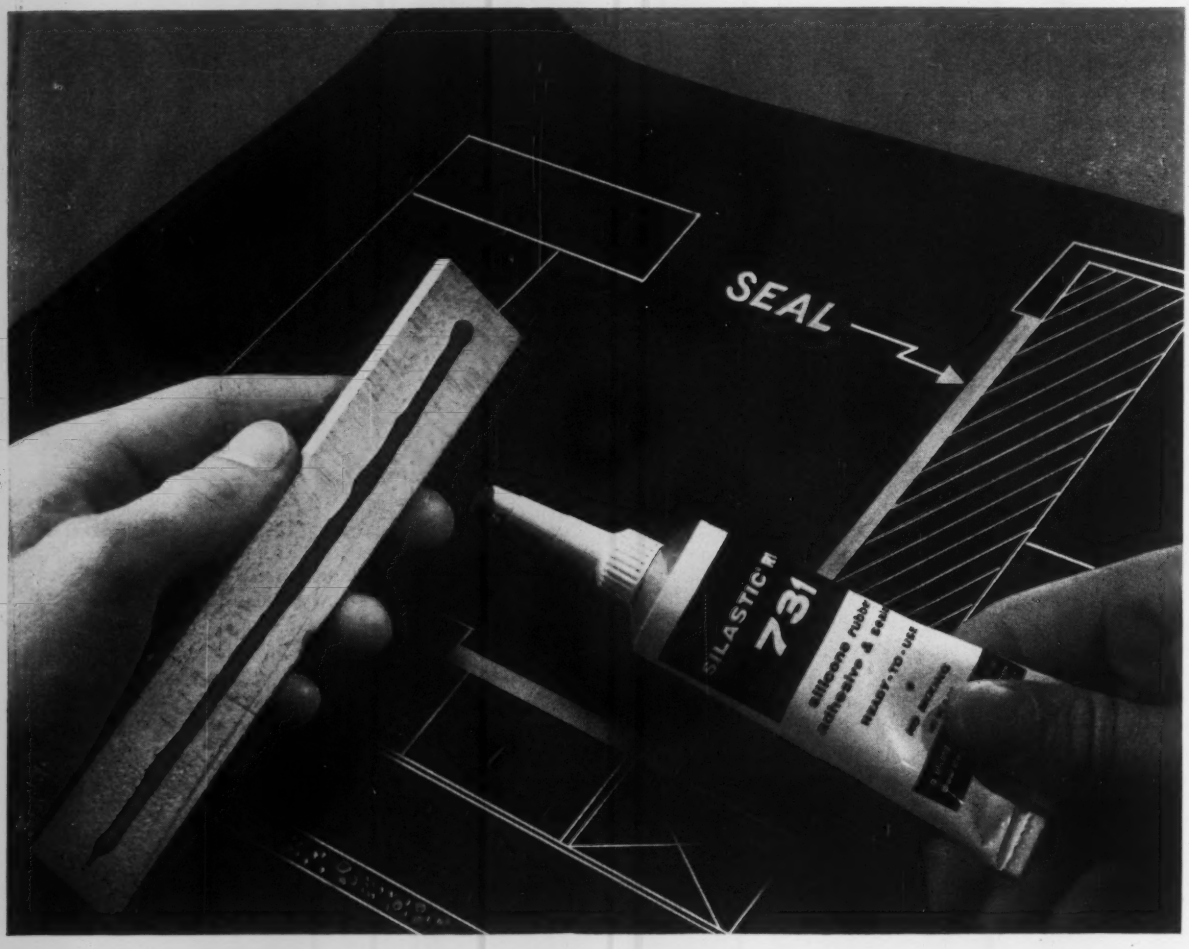
Company_____

Address_____

City_____ Zone_____ State_____

SILICONE NEWS from Dow Corning

Stops leaks permanently



New rubbery adhesive seals out moisture, dust, contaminants

Here's a really durable, silicone rubber sealant that sets-up at room temperature and bonds permanently to most materials, including metals and plastics. Silastic® RTV 731 has the easy-to-use consistency of toothpaste and is supplied ready for application in handy tubes.

Silastic RTV 731 flows out smoothly, clings to most materials, won't sag or slump when applied to vertical surfaces. It quickly sets-up on exposure to air and cures *without heat* to form a tough, flexible silicone rubber seal.

Seals made of Silastic RTV 731 show no loss of either adhesion or flexibility when exposed to low pressure steam, moisture, high humidity or corrosive atmospheres at temperatures ranging from —100 to 500 F. This sealant offers solutions to all types of sealing and bonding problems. Wherever your blueprints call for sealing, it will pay you to look into Silastic RTV 731.

Write for "Greater Versatility with Silastic RTV." Address Dept. 7423a, Dow Corning Corporation, Midland, Michigan.

first in silicones

Dow Corning

For more information, turn to Reader Service card, circle No. 340

IF YOU'RE UP IN THE AIR
OVER HIGH TUBING COSTS

Call Us Early

Down-to-earth tubing costs—that's what you get from an early call to a Rochester Steel Tubing Expert. Our Specialists are trained to value-analyze tubing problems—recommend applications that can lead to faster production and lower costs. And what Rochester recommends, Rochester delivers. Take serpentines as a case in point. Rochester might adapt one of its multiple benders to your individual requirements. Such a recommendation could save tooling costs and reduce lead time on your line. And that's just the beginning. Because Rochester straightens all serpentines, they lie flat as a pancake. This flatness speeds production by making it easier to hold serpentines in wire-welding fixtures. To lower your tubing costs, put in an early call for the Rochester Tubing Sales Manager. He'll send help fast.

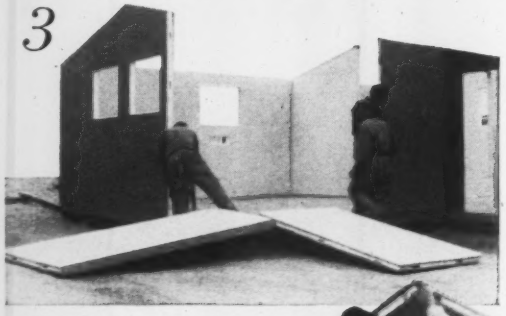
RP

STEEL TUBING BY ROCHESTER PRODUCTS

ROCHESTER PRODUCTS DIVISION OF GENERAL MOTORS. ROCHESTER. NEW YORK

For more information, turn to Reader Service card, circle No. 431

how to build a house in a day...



1 Floor panels are locked to joists laid on permafrost ground.

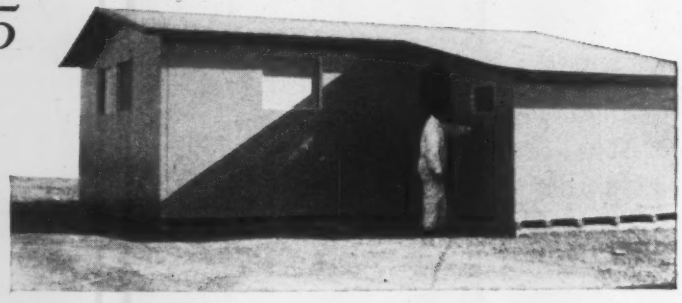
2 Doorway is first wall panel to go up. It locks to floor.

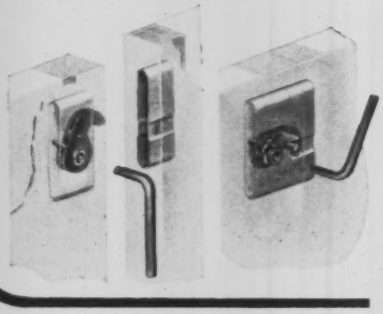
3 Walls and partitions lock to floor and to each other.

4 Roof panels go on last. This takes about three hours.

5 Complete in 7 hours! Floor, walls, roof panels—It's all done with Simmons Dual-Lock fasteners.

Standard Dual-Lock withstands 2500-lb. tension; may be modified for high-load applications to 4500 lbs.





■ This house is put up in a day—and can be taken down in half a day!

■ Key to quick assembly-disassembly is the Simmons Dual-Lock.

Dual-Lock is a high-load, positive-locking structural fastener perfectly adapted to panel fastening of demountable shelters, shipping containers, covers, cowlings... and to all butt-joint fastening jobs. It can be recess-mounted as in the application pictured, or surface-mounted on sheets or panels. Locks with heavy closing pressure, with very light pressure required on the key.

Arctic Units, Ltd., Toronto, Canada, is putting up 90 "Eskimo Houses" on the DEW Line. Panels, including roof, are plywood-covered plastic foam designed for insulation against Arctic cold.

WRITE FOR CATALOG 760. Complete details of Dual-Lock and other dependable quick-operating Simmons Fasteners with unlimited money-saving applications.

■ Samples and engineering service available upon request.

SIMMONS FASTENER CORPORATION

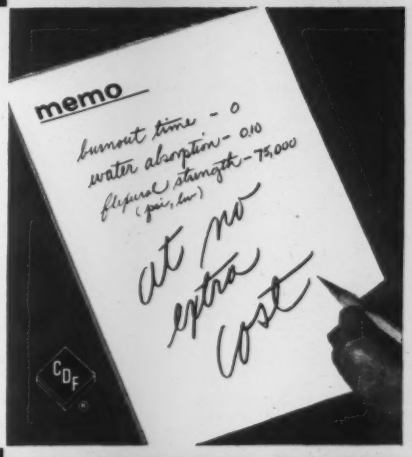
1759 North Broadway, Albany 1, New York

LINK-LOCK • HINGE-LOCK • HOOK-LOCK • SPRING-LOCK • CAM-BOLT • DUAL-LOCK • QUICK-LOCK • ROTO-LOCK

For more information, turn to Reader Service card, circle No. 433

New Copper-Clad *Reliability*

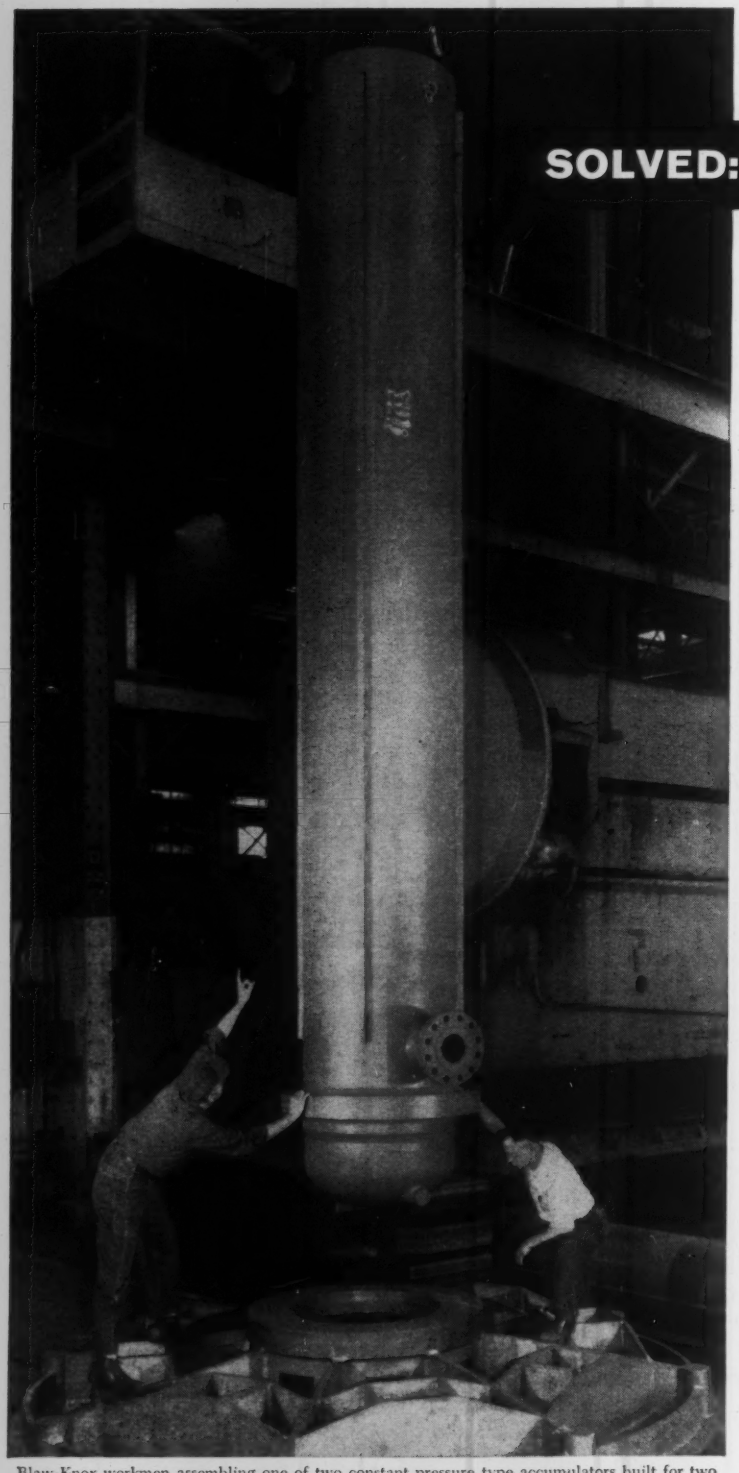
In March, 1961, CDF Grade 614, glass-epoxy laminate, was announced . . . and met with almost overnight acceptance. Particular electronics and electrical manufacturers wasted no time in specifying this premium performance material with zero burnout and minimum "haloing."



By June, 1961, CDF Grade 614 had become the new standard of comparison for applications in critical ground and air-borne circuitry. Designers like its specifications, production men like the way it handles, management likes its reasonable price.

Now, CDF Grade 614 Copper-Clad is setting a new pace among particular producers of printed circuits . . . offering a new high in reliability for high packaging densities . . . and offering researchers a new tool in the investigation of molecular and submicro-circuitry.

You can take advantage of 614 Copper-Clad's unique features right now . . . in research, development or production operations. Continental-Diamond Fibre Corporation, Newark, Delaware. A Subsidiary of the Budd Company.



Blaw-Knox workmen assembling one of two constant pressure type accumulators built for two of America's largest steel mills. Sandusky supplied the straight cylindrical sections for both.

SOLVED: by Sandusky Centrifugal Casting

Blaw-Knox chooses 10-ton

SANDUSKY CASTING

for giant slabbing mill

When an 18½-foot cylinder was needed for a new giant Universal slabbing mill built by Blaw-Knox Company's East Chicago (Indiana) Works for a well known steel mill, they found that the most practical and economical way to meet all requirements was with a Sandusky Centrifugal Casting.

This 10-ton carbon steel cylinder, 32" O.D. with a 3½" wall, functions as an accumulator in the mill's hydraulic roll balancing system. Essentially a pressure vessel, it simultaneously supports the ram and ballast weighing 226 tons—the weight required to develop constant operating pressure of 1000 p.s.i.

"Only a dimensionally stable, one-piece cylinder could perform satisfactorily in this service," a Blaw-Knox official asserted. *"Distortion could lead to binding, loss of pressure and costly downtime. Sandusky's ability to produce this heavy walled cylinder in one 18½ foot length met all our requirements of cost, stability, and strength."*

Sandusky cylinders up to 33 feet long —from 7" to 54" O.D.— and in a wide range of ferrous and non-ferrous alloys —may well be the answer to *your cylindrical problems,* too.

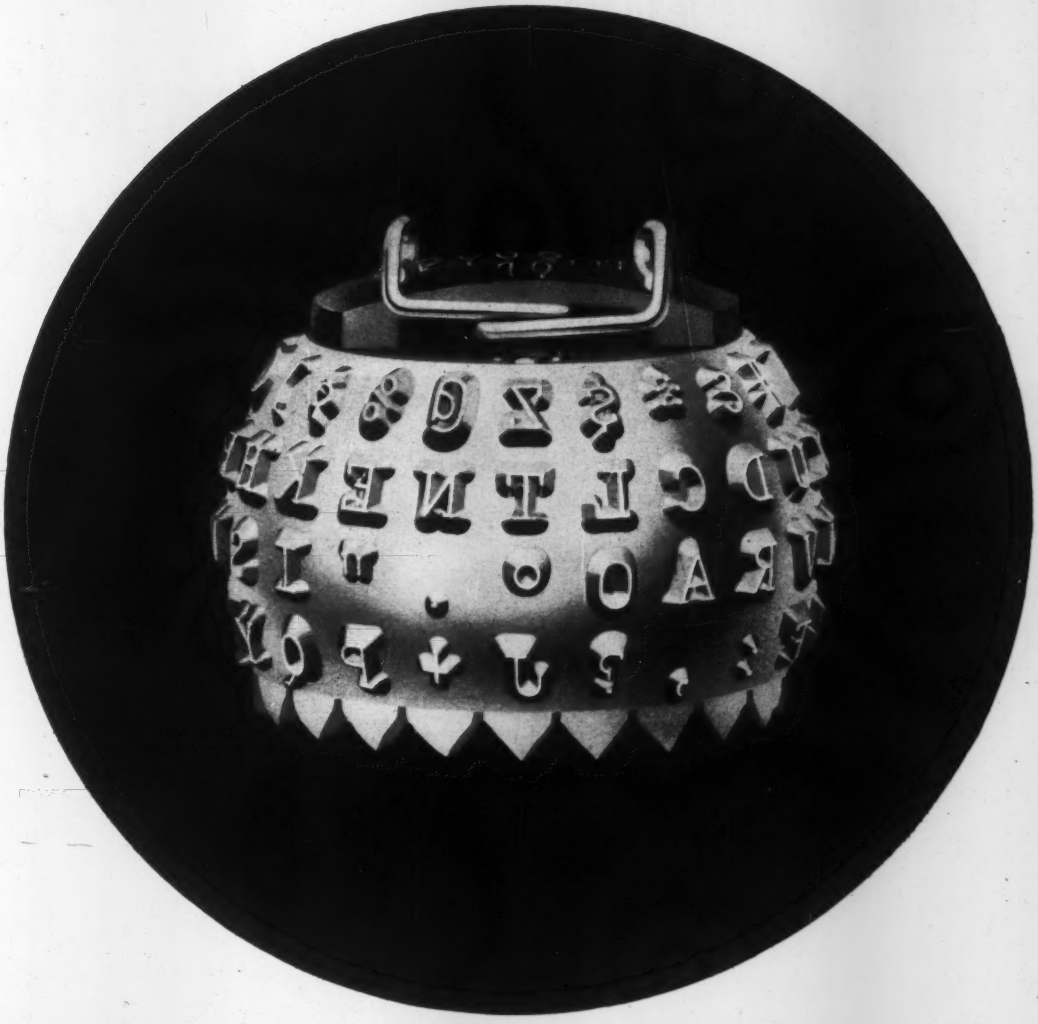
Write to us at Sandusky, Ohio. Ask for latest Bulletin #200.

SANDUSKY CENTRIFUGAL CASTINGS

FOUNDRY & MACHINE CO.

SANDUSKY, OHIO—Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

For more information, turn to Reader Service card, circle No. 382



Plaskon UREA...ENABLES IBM TO MOLD A NEW WAY TO WRITE

The precision engineered typing element of IBM's new Selectric® carriageless typewriter is molded of PLASKON® UREA.

No bigger than a golf ball, this nickel-plated urea sphere does the work of a basketful of type bars—tilting and rotating at high speed as it selects and types the desired character or symbol.

According to IBM, many materials were checked for impact strength, resistance to acids, shrinkage and adaptability to molding. Plaskon Urea was the choice: It was selected because it has the best combination of those properties required.

Plastics Division offers complete research and technical assistance to help you with your design and molding problems.

PLASTICS DIVISION
40 Rector Street, New York 6 N. Y.

Allied Chemical
BASIC TO AMERICA'S PROGRESS

For more information, turn to Reader Service card, circle No. 455

Take a lead from the leaders...

Amchem ALODINE* Improves Adhesion of Coated Coil in

Fifteen years and many millions of pounds of Alodized painted aluminum and Granodized steel sum up Comaco quality.

Corrosion Resistance, Paint 15-Year Record at COMACO

Mr. Roland Harrison, President, Comaco, Inc.

"PAINT ADHESION IS THE SINGLE MOST IMPORTANT FACTOR IN OUR OPERATION—ALODINE GIVES US THE BEST POSSIBLE PAINT JOB"

In producing custom coated coil and strip, awnings, storm and screen doors and aluminum building products, a reliable paint finish is the "showcase" of quality upon which customers judge the product. At Comaco, Inc., Bakerstown, Pa., the answer to superior paint adhesion has been the Alodine chromate conversion coatings, specified and used almost since the company's inception.

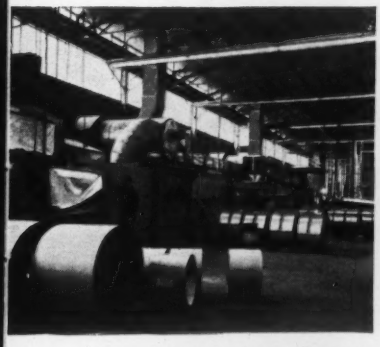
Over 15 years, the Alodine process has pre-treated millions of pounds of aluminum to provide superior paint bonding and increased corrosion resistance for Comaco end products.

Recently, Comaco who also produces coated steel strip, switched from a competitive phosphate coating process to Amchem Granodine**, has achieved considerable savings in chemical cleaners and treatments. Comaco finds Amchem technical service "definitely superior." Independently conducted quality tests by Comaco, Amchem and Comaco's paint supplier show Comaco-produced, Alodine- and Granodine-treated metals to have maximum paint adhesion.

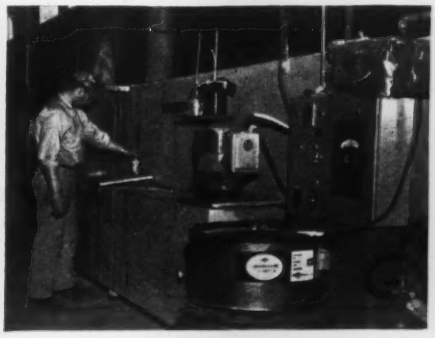
When you need conversion coating for steel or aluminum and competent technical service *take a lead from the leaders* and specify Amchem for all-around superiority. There's a local Amchem Representative near you and he's a metal protection expert.

*Amchem's registered trademark for its conversion coating chemical for aluminum.

**Amchem's registered trademark for its conversion coating chemical used to produce phosphate coatings on steel.



General overall view of Comaco's 40-inch combination Alodine and Granodine metal preparation line.



Operator controlling chemical flow in Granodine tank. Six-stage line accommodates both aluminum and steel.

Comaco inspector makes visual inspection of coated coil being run through the paint coater.

AMCHEM **ALODINE**

Amchem is a registered trademark of

AMCHEM PRODUCTS, INC. (Formerly American Chemical Paint Co.)

AMBLER, PA. • St. Joseph, Mo. • Detroit, Mich. • Niles, Calif. • Windsor, Ont.

For more information, turn to Reader Service card, circle No. 468

FOUNDATION makes the difference!

The Interlox line was developed to give you a better, lower cost, easily controlled phosphate coating. Its exceptional cleaning ability combined with a radically different type of accelerator produces an even, fine grained, dense coating which locks your organic finish to the metal.

Interlox eliminates streaks, stains, powdery deposits, and flash rusting, giving you the ultimate in appearance, adhesion and resistance to humidity and salt-spray.

Additional cleaning power is easily obtained, when desired, by the addition of a low-cost detergent only, thus avoiding the danger of over-phosphatizing and the costly practice of adding complete phosphatizing compound when only cleaner is required.

There is an Interlox product developed to meet your particular need whether spray or immersion type, single or multiple stage. Interlox baths are unusually long lived and require less additions and control.

Licensed Manufacturers

Alert Supply Co. Los Angeles, California
Armalite Company, Ltd. Toronto, Canada

NORTHWEST CHEMICAL COMPANY
9310 ROSELAWN • DETROIT 4, MICHIGAN
CHEMICAL PRODUCTS DIVISION • CHEMETRON CORPORATION

For more information, turn to Reader Service card, circle No. 363

Steel
for Strength
. . . Economy
. . . Versatility

Tool Steel Topics

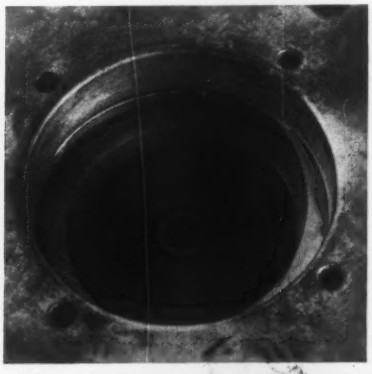
BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

Seals for jet engine starter cartridges blanked with Lehigh H

The job was tricky. It involved cutting 6-in. circles from .002 in. Mylar, a plastic material used for vapor seals in jet engine starter cartridge parts because of its high strength and resistance to tearing. Bethlehem Lehigh H tool steel was selected by Seymour Manufacturing Co., Seymour, Indiana, who designed and built the die for Amoco Chemicals Corp. Lehigh H was a wise choice. The die, made to extremely close tolerances, blanked the material cleanly, and produced nearly 140,000 pieces before slight redressing was required.

Lehigh H (AISI D-2) is our easy-machining high-carbon, high-chrome grade of air-hardening tool steel. It has high compressive strength, deep hardenability, and excellent resistance to wear.



Lehigh H has wide range of metal working uses

Because of its ideal properties, Lehigh H is used for blanking, forming, punching, shearing, bending, and other tool and die jobs. It's frequently used for rotary slitting cutters, wearing plates, and thread-roller dies.

Good things happen when you put Lehigh H on the job. Your local Bethlehem tool steel distributor can make prompt delivery.

Call him today for complete details.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

"Wear-In" of Tools Must Be Handled with Care

The initial use of new tools is the most critical period of operation. For example, during the "wear-in" period, the working surfaces of a drawing die and its mating punch may gall or "pick-up" portions of the metal being formed. This condition must be detected soon after it occurs, then removed promptly by hand stoning, to prevent further surface damage to the tools. If it is not detected and removed, heavy scoring and seizing may occur, producing not only short tool life but defective parts as well.

Obviously, the use of an effective lubricant will decrease "wear-in" problems, but even the best lubrication practice may not be sufficient protection on many operations. For example, a combination of tools and lubricant which performs well in processing soft steel may be troublesome in working stainless stock. Close attention to such tools during "wear-in" will delay the "wear-out" period.

Air-4 Tool Steel Machines with Ease.

Bethlehem Air-4 is a medium-alloy tool steel which hardens in air at 1550 F. It has excellent free-machining characteristics, due to a carefully controlled addition of lead. Air-4 also has plenty of wear-resistance, toughness, and deep-hardening properties. It can also be heat-treated without running any danger of cracking.

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

by Fred E. Graves

Nuts have performance 'designed in'

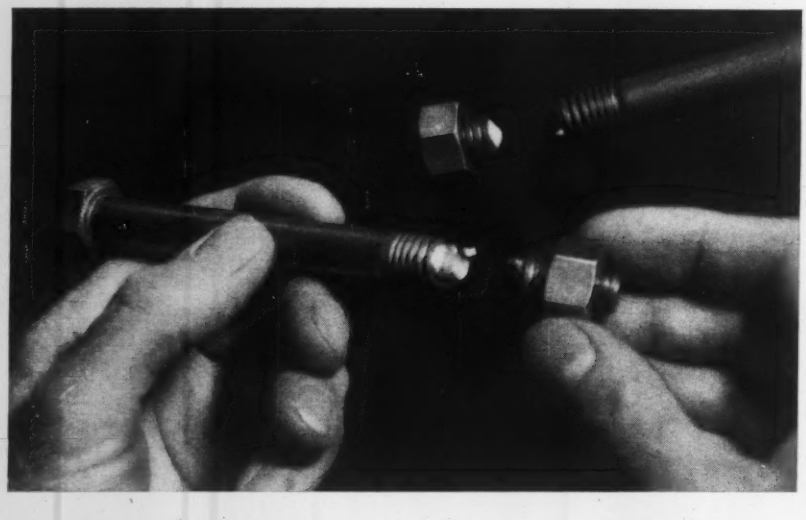
A standard nut isn't as simple as it looks. Much design know-how goes into its manufacture. Proper design avoids these pitfalls.

1. Thread shear: Several factors cause this. The nut may not be high enough to contain sufficient threads; its material may lack plasticity that enables it to deform under tightening so that enough threads engage and distribute the load to avoid progressive shear.

2. Wall dilation: The inclined-plane effect of the thread's helix angle resolves torque on a nut into two components: vertical (shear) and horizontal (dilation). Dilation enlarges nut's diameter, shifting the load towards weaker *tips* of threads.

3. Crushing: Nuts that aren't wide enough across the flats bear down on too small a surface. High unit stress may crush the bearing surface, with relaxation of bolt tension the undesirable end result.

Reputable fastener manufacturers provide you with ASA "Finished" nuts having enough height to sustain high thread tension, sufficient wall thickness to control nut dilation under load, and the right amount of bearing area. Nuts manufactured for ASA's "Heavy" series are higher and ¼-inch wider across flats for added bearing area and wall thickness. They are generally used with high strength bolts or when bolt holes have large clearances.



Sintered nuts are so strong bolts fail before they do!

IN A brute force test of strength, sintered stainless-steel nuts and cold-headed standard hex screws were assembled and pulled apart in a tensile tester to determine what would fail first.

Results you see pictured above—½ inch hex bolts, stretched to failure. But their sintered nuts show no damage, either to internal threads or wall.

QUALITY GOVERNS STRENGTH

What gives sintered products their strength? At RB&W it's strict attention to purity of raw metal powders plus carefully-controlled mixing, compacting, and sintering. Also special heat treatments.

The table shows typical proof loads achieved by RB&W sintered nuts. They're more than ample for the bolts. Full size range available.

Size	Material	Proof Load (lbs.)
¼-20	*Brass	2060
¼-20	**18-8 Stainless Steel	3800
⅜-16	*Brass	5000
⅜-16	**18-8 Stainless Steel	9300
½-13	*Brass	9200
½-13	**18-8 Stainless Steel	17050

*Equivalent to screw stress of 65,000 psi
**Equivalent to screw stress of 120,000 psi

OTHER PHYSICAL ADVANTAGES

These nuts have excellent surface finish. Holes are perfectly round; threads are thus precisely tapped.

Perfectly dimensioned, corners filled out, chamfers uniform—each sintered nut is an exact reproduction of the other.

The same quality workmanship and facilities which fashion RB&W's stainless steel and brass sintered nuts are also at your service for sintering special parts. Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Sales office and warehouse at: San Francisco, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago.

For more information, turn to Reader Service card, circle No. 365

ARE YOU ACQUAINTED WITH THE NEWEST ADDITION TO UNION CARBIDE'S FAMILY OF PLASTICS

BAKELITE®
POLYPROPYLENE

High heat resistance

●

No stress cracking

●

Lowest specific gravity

●

Outstanding flex life

●

Easy processability

●

Good mechanical, electrical and chemical properties

●

Economical

●

Low MVT and low gas permeability

Investigate BAKELITE® Polypropylene for MOLDING AND EXTRUSION

(All formulations except food grades are heat stabilized for prolonged use at elevated temperatures)

GENERAL PURPOSE: for molding and extrusion.

HIGH IMPACT: 3 to 5 times tougher than general-purpose materials.

FOOD APPLICATIONS: FDA-sanctioned

HIGH FLOW: for deep-draw moldings

U-V STABILIZED: for outdoor applications

BLOW MOLDING: short flow for parison stability

THERMOFORMING: non-sagging

We would be glad to discuss polypropylene or any of our other plastics materials with you. These include high, medium, and low density polyethylene, polyethylene copolymers, phenolics, styrene, epoxy and vinyl resins and compounds. Simply fill out the adjacent coupon.

UNION CARBIDE PLASTICS

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

Union Carbide Plastics Company
Division of Union Carbide Corporation
Dept. KQ-85K, 270 Park Avenue, New York 17, N.Y.

I am interested in the possibilities of using polypropylene for _____

NAME _____

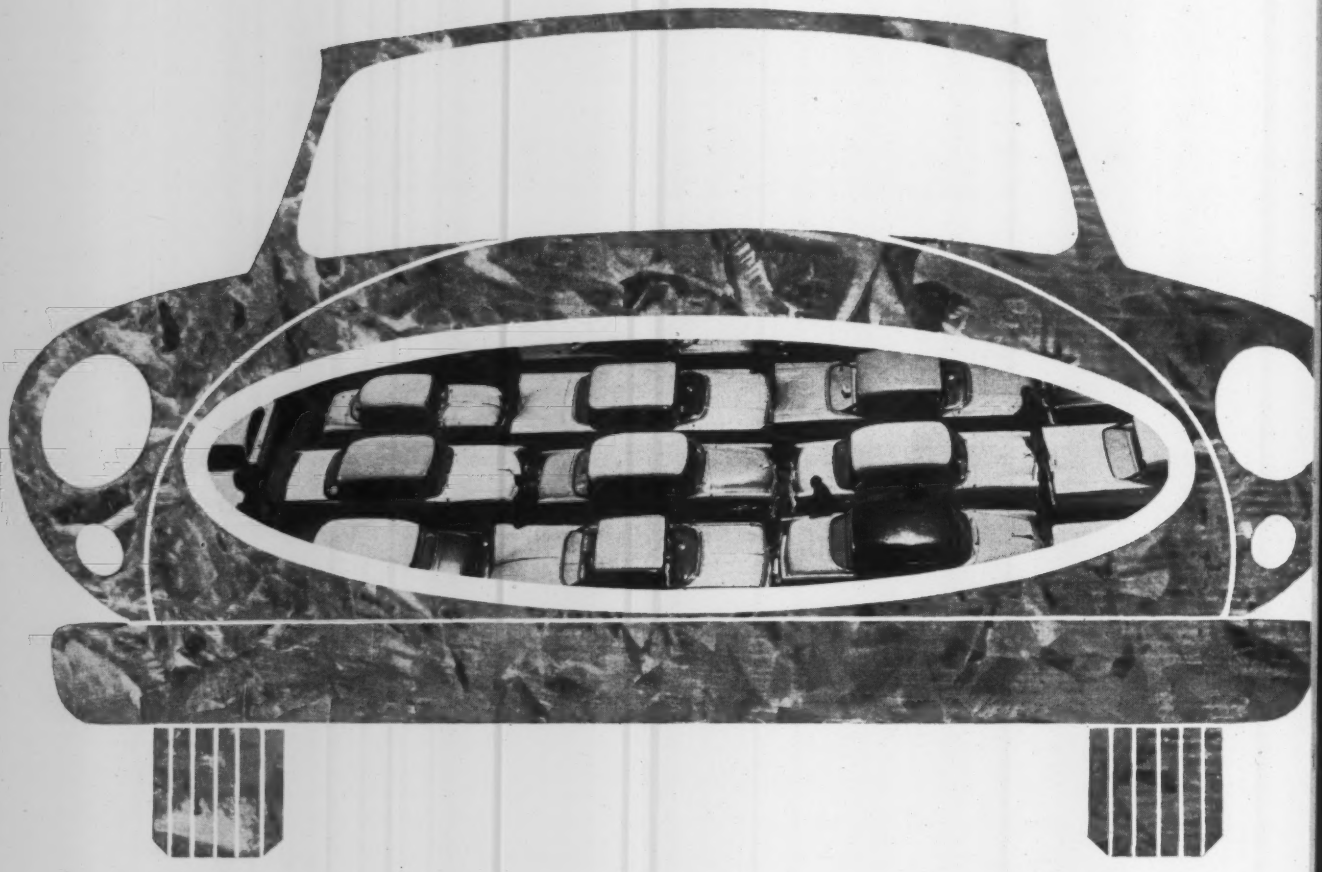
FIRM _____

ADDRESS _____

CITY _____ ZONE ____ STATE _____

For more information, turn to Reader Service card, circle No. 446

More parts in more new cars fend off corrosion . . .



GUARDED BY GALVANIZED STEEL

In 1960 the Motor City consumed a massive 218,964 net tons of galvanized steel sheets to fight car corrosion. That's 38% more than was used in 1959 and over 700% more than in 1954.

In the average compact car, for instance, Detroit now uses over 100 pounds of corrosion-resistant galvanized steel sheets. The results are numerous and notable: Car owners are getting greater durability and a sharp drop in maintenance costs and headaches. Manufacturers are getting the cost reductions inherent in galvanized steel's simplified fabricating procedures. Head and tail lamp housings, for instance, formerly required five or six steps when zinc plated or painted after stamping. Now they are moved direct from press to assembly line with their tight zinc coatings completely undamaged by fabrication. The same economies apply to side members, rocker panels, front and rear rails and cross members.

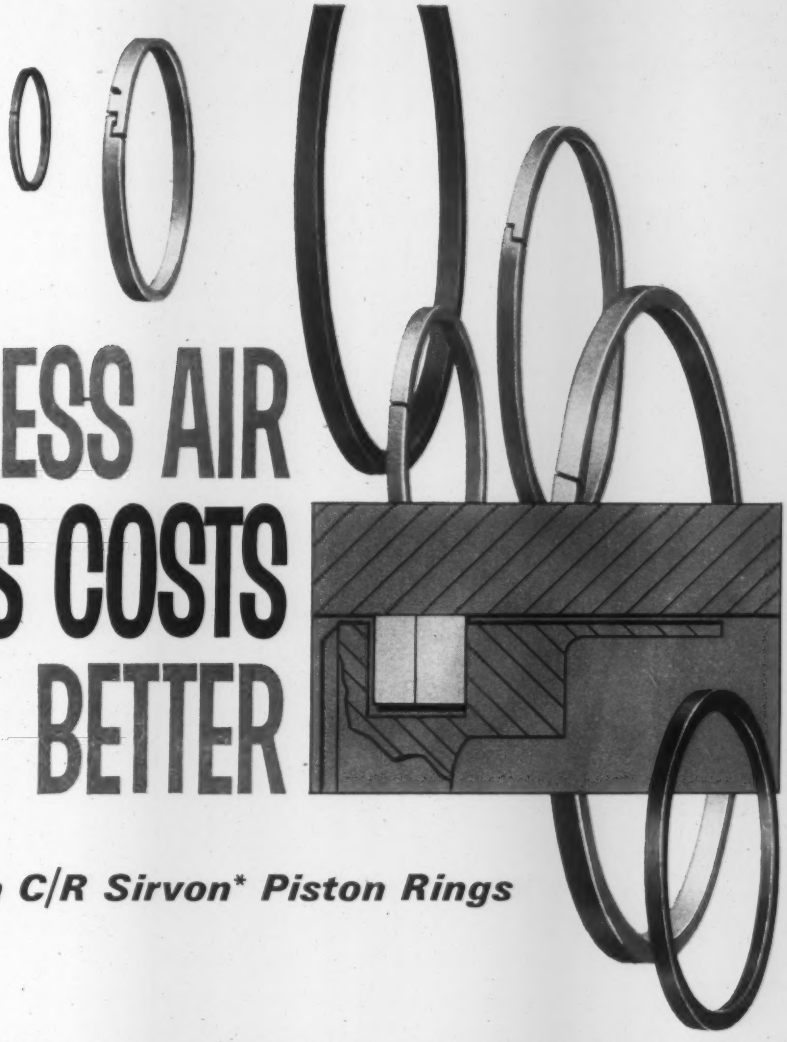
WEIRKOTE,® IN PARTICULAR! Widely used Weirkote is a natural for automotive applications, and the auto industry has been quick to put it to extensive use. To the inherent strength, economy and versatility of steel, Weirkote adds enduring zinc protection that can be worked to the very limits of the steel base without chipping or peeling. This superior product is the end result of years of experience and technical research devoted to coating steel sheets with zinc. Weirkote is manufactured by two National Steel divisions, Weirton Steel and Midwest Steel. Write Weirton Steel Company, Weirton, West Virginia, for further details.

MIDWEST STEEL
Portage, Indiana

WEIRTON STEEL
Weirton, West Virginia

Divisions of
NATIONAL STEEL CORPORATION

For more information, turn to Reader Service card, circle No. 346



COMPRESS AIR COMPRESS COSTS BETTER

when you design-in C/R Sirvon Piston Rings*

Here's how well they're working now—for others:

Case 1—In air: Two split Sirvon rings in one groove were used in a small portable compressor under these conditions: speed 1725 rpm, stroke .352", pressure 75 p.s.i., output air temperature 100°F. No lubricant. After discontinuance of testing at 2000 hours, the rings were still in excellent condition, functioning perfectly. Other applications require only a single ring.

Case 2—In oil: A leading farm equipment manufacturer has tested and approved C/R Sirvon solid rings for a hydraulic application at pressures up to 2000 p.s.i., and shock pressures to 2500 p.s.i. in fluid equivalent to S.A.E. #10 oil. (Rings have been applied in special cases under pressures up to 8000 p.s.i.)

Consider these advantages

Right now Sirvon rings are permitting important cumulative economies in pneumatic and hydraulic units for both manufacturer and user.

1. Sirvon rings can run bone-dry where oil might contaminate the system.
2. Friction loss is greatly reduced by the low coefficient of the base resins.
3. Low-friction Sirvon rings greatly increase service life — eliminate cylinder scoring.
4. Piston design is simpler, less costly.
5. Ring installation is simple, assembly costs less.
6. Leakage is reduced.

Further, Sirvon rings are practicable for use in almost any air, gas, or fluid medium. They are inert to all commercial chemicals except hydrofluoric acid and molten alkalies, and will operate at temperatures from −400 to +500°F.

Why C/R Sirvon Piston Rings?

Because Chicago Rawhide is already an acknowledged leader in the field. C/R has experience in the complex technology required for compounding, molding or extruding piston rings with correct thermal stability, wear resistance and dimensional accuracy. In short, C/R knows how—now—and is producing dependable rings in large quantities for major users. C/R Sirvon engineers will welcome the opportunity to work with you.

Free sample: Tell us the size ring you would like to see. We'll send you a free sample Sirvon ring in that range. No obligation, of course.

*"SIRVON" C/R's trade name for fluorocarbon resin based compounds. In this case the base was "Teflon" (Du Pont Registered T. M.)

CHICAGO RAWHIDE MANUFACTURING COMPANY

1227 Elston Avenue • Chicago 22, Illinois

Offices in principal cities

See your telephone directory

In Canada: Chicago Rawhide Products Canada Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

For more information, turn to Reader Service card, circle No. 412

STRENGTH + LIGHT WEIGHT
That's the Beauty of Steel

DESIGN NOTE: The Military Ranger used N-A-XTRA 90 (minimum yield strength, 90,000 psi) in bars and plates ranging to 1" thick, in main frame and cross members, loader mechanism and fork carriage. Fabrication followed standard gas cutting and welding procedures. Excellent weldability of N-A-XTRA was important in joining to other steels.

N-A-XTRA 90 plates and bars are used in the "Ranger," a rough terrain military vehicle designed, dereloped and fabricated jointly by the U. S. Army Quartermaster Corps and the Clark Equipment Company, Battle Creek, Michigan. The Ranger series is manufactured by the Industrial Truck Dirision of Clark Equipment Company.

Great Lakes Steel is a Division of

ROUGH TERRAIN MILITARY FORK TRUCK USES

N-A-XTRA

HIGH-STRENGTH STEEL FOR MAXIMUM LOADABILITY WITH MINIMUM WEIGHT

The U. S. Army needed a material handling truck in 6, 10 and 15 thousand-pound-capacity sizes that would, among other things, operate in five feet of salt water . . . traverse sand beaches, rough terrain . . . climb 45% grades at a minimum of 2.0 m.p.h. . . . 15.0 m.p.h. loaded on the highway . . . load and unload from the far side of a flat car . . . tilt loads 30 degrees back, 45 degrees forward, 10 degrees from the horizontal left or right. *And all this within dimensional and weight requirements that would allow air transport of the vehicle.*

The U. S. Army Quartermaster Corps and the Industrial Truck Division of Clark Equipment Company came up with the answer—the Military Ranger. It meets or exceeds every operating requirement. And does it within the vital weight limit by using N-A-XTRA 90 high-strength steel in main frame, cross members, loader mechanism and supporting structure. N-A-XTRA handles the job in these high-stress areas, yet weighs three times less than mild carbon steel of equivalent strength.

You may never have to air-lift your equipment, but that's not the only problem N-A-XTRA solves. Rugged operating conditions, heavy loads and weight-saving construction—in such applications as, for example, heavy machinery and pressure vessels—are challenges that N-A-XTRA is designed to meet and beat.

With excellent weldability, formability, and toughness even at subnormal temperatures, N-A-XTRA low carbon, extra-strength alloy steels give superior results with conventional fabricating methods, including cold forming, gas cutting, shearing and machining. N-A-XTRA high-strength steels are available in four levels of minimum yield strength, from 80,000 to 110,000 psi, and in sizes ranging from $\frac{1}{8}$ to $1\frac{1}{4}$" thick, up to 72" wide and up to 35' long. For further information, write Great Lakes Steel Corporation, Product Development, Dept. MDE-16, P. O. Box 7310, Detroit 2, Michigan.

N-A-XTRA
HIGH-STRENGTH STEELS

a product of

GREAT LAKES STEEL

Detroit 29, Michigan

N-A-XTRA STEELS ARE AVAILABLE AT THESE STEEL SERVICE CENTERS

Benedict-Miller, Inc. Lyndhurst, New Jersey	Joseph Demsey Co. Cleveland, Ohio	Ducommon Metals & Supply Co. Los Angeles, California
Interstate Steel Co. Des Plaines, Illinois	Lockhart Iron & Steel Co. Pittsburgh, Pennsylvania	Marsh Steel & Aluminum Co. Kansas City, Missouri
O'Neal Steel, Inc. Birmingham, Alabama	Salt Lake Hardware Co. Salt Lake City, Utah	A. C. Leslie & Company, Ltd. Montreal, Canada

NATIONAL STEEL CORPORATION

For more information, turn to Reader Service card, circle No. 434

Designing for HIGHER PERFORMANCE?

. . . consider the advantages of ALITE

If you are designing a new product, or seeking new ways of improving existing ones, designing for Alite high-alumina ceramic may be your most profitable approach.

Because of its unique physical, chemical and electrical properties, this rugged and versatile material has proved successful in many highly critical applications, thus solving difficult design and production problems in a wide range of industrial fields.

Alite withstands high heat, shock and abrasion. Permits you to design for higher temperatures and greater strength. It can be supplied in practically any shape, finished to exacting tolerances. Alite has excellent properties for use as bushings, bearings, valve seats, pump parts, wear plates, wire guides, spools and cores. Any job that demands high mechanical strength and wear resistance, chemical resistance, or reliable performance at elevated temperatures, is a possible application for Alite.

Important ALITE properties

- Extremely hard, strong, chip-resistant
- Chemically inert—superior corrosion resistance
- Vacuum-tight—can be metallized and brazed to metal for hermetic seals
- High thermal shock and heat resistance—working temperatures to 1725°C.
- Remains stable under nuclear radiation
- Superb dimensional stability
- Excellent dielectric characteristics

For complete description of Alite, plus data on Alite Ceramic-to-Metal Seals, write for Bulletins A-8 and A-40R.

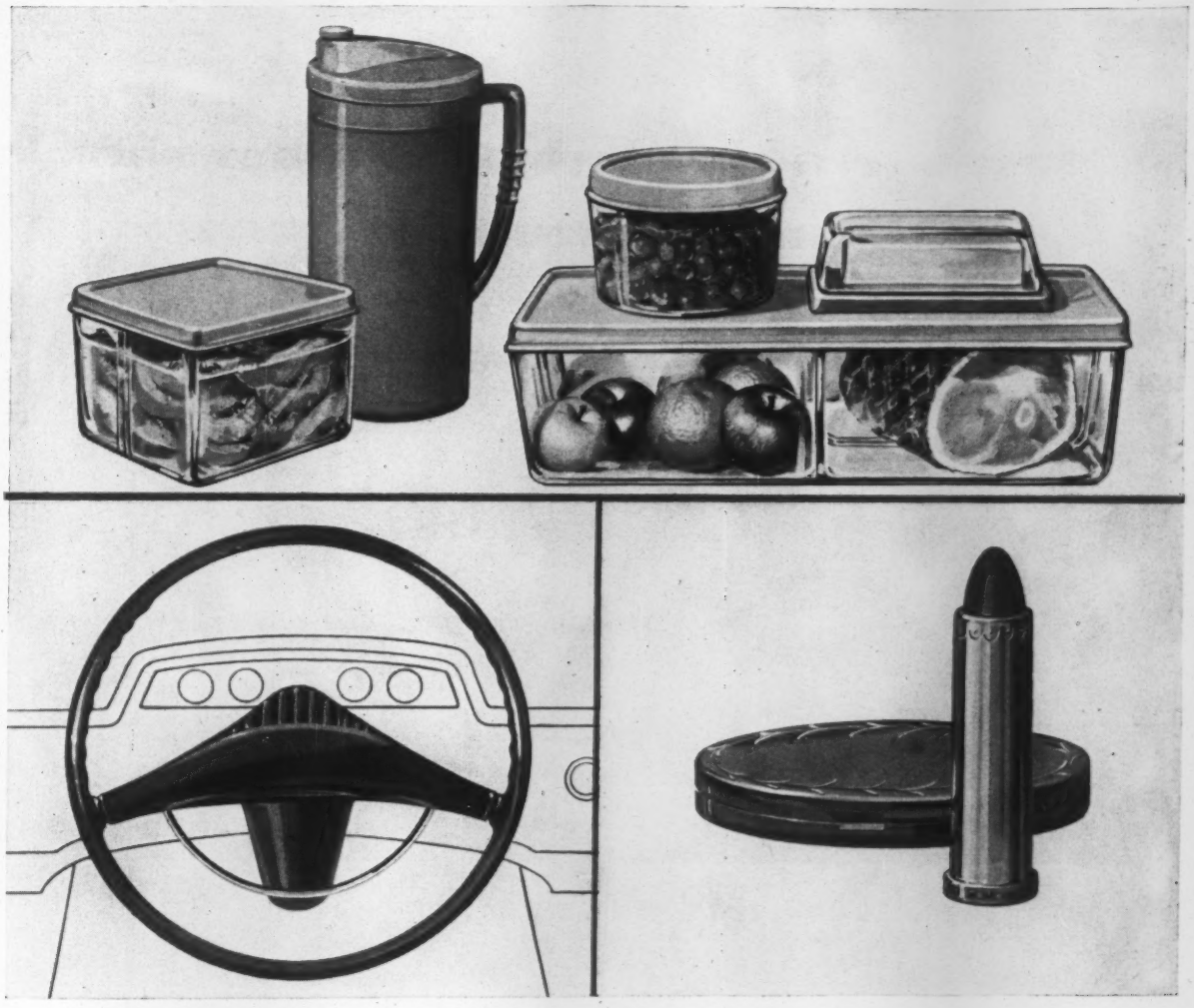
117F-3

U. S. STONEWARE

BOX 119 ORRVILLE, OHIO

ALITE DIVISION

For more information, turn to Reader Service card, circle No. 362



Specify Escon® polypropylene for low odor pick-up

Escon has no taste or odor of its own and is highly resistant to stain and odor pick-up. This important property makes Escon an excellent choice for food storage containers and packaging, compacts and lipstick cases—even automobile steering wheels.

Escon polypropylene offers manufacturers a *balanced* combination of properties for high-speed, profitable production—including resistance to dynamic fatigue, high strength, chemical and abrasion resistance, and many more. Expert technical assistance is always available. For full details, write to Enjay, 15 West 51st Street, New York 19, N. Y.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

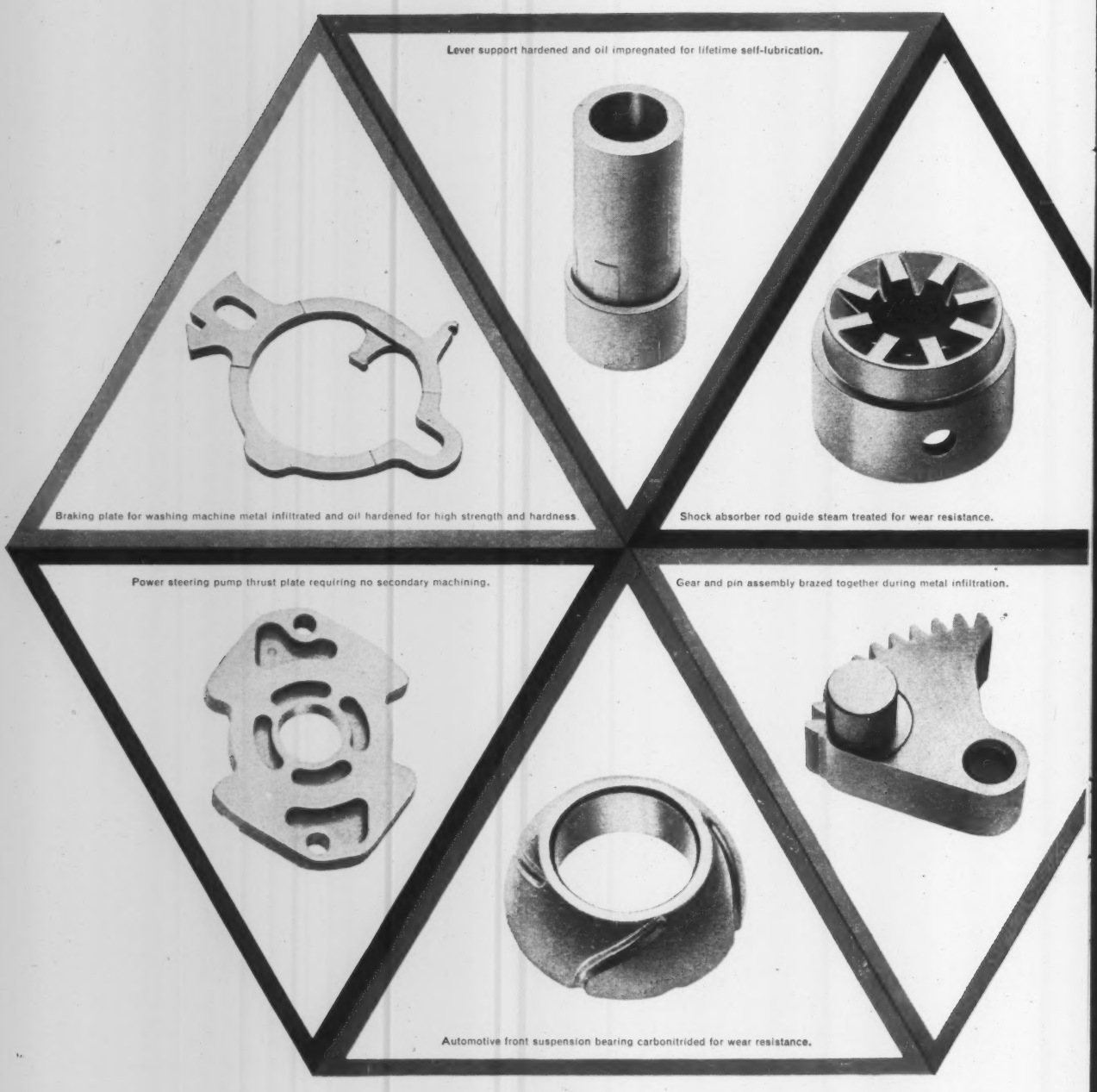
ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY

For more information, turn to Reader Service card, circle No. 335

LOOK WHAT YOU CAN GET FROM


Lever support hardened and oil impregnated for lifetime self-lubrication.
Braking plate for washing machine metal infiltrated and oil hardened for high strength and hardness.
Shock absorber rod guide steam treated for wear resistance.
Power steering pump thrust plate requiring no secondary machining.
Gear and pin assembly brazed together during metal infiltration.
Automotive front suspension bearing carbonitrided for wear resistance.

DELCO MORAINE SINTERED METALS NOW:

Characteristics peculiar to sintered metal place it in a unique position in the metal forming industry. It provides a way to form shapes which are impractical to form by any other means. It permits combination of metals and non-metals which cannot be combined by other processes. It makes possible controlled density or controlled porosity, a fact significant in certain applications. Sintered iron and steel lend themselves to special processes if the application requires special hardness or strength.

Which of these will make sintered metal useful to you?

OIL HARDENED PARTS

Ferrous sintered metal with sufficient combined carbon can be oil hardened to a particle hardness of R_C55 minimum. In addition to the increased wear resistance obtained by hardening, controlled porosity and self-lubrication are retained.

STEAM TREATED PARTS

Iron base materials may be subjected to steam at an elevated temperature to effect controlled surface hardening and sealing. The surface is economically coated with a hard, tight film of wear-resistant black iron oxide.

METAL INFILTRATED PARTS

Certain parts are infiltrated with a copper base alloy to obtain high tensile and compressive strength. Machinability and modulus of elasticity are improved. Separate pieces may be brazed together during this process.

CARBONITRIDED PARTS

Iron base materials may be case hardened by the carbo-nitriding process. This results in a particle hardness of R_C60 minimum that provides maximum wear resistance. The full impact strength of the core is retained.

PRECISION PARTS WITHOUT MACHINING

When the design recommendations of Delco Moraine engineers are followed, many complicated structural parts may be readily manufactured in large quantities to exacting specifications without secondary machining operations. Reliability and consistency of the parts are inherent.

METAL INFILTRATED AND HARDENED PARTS

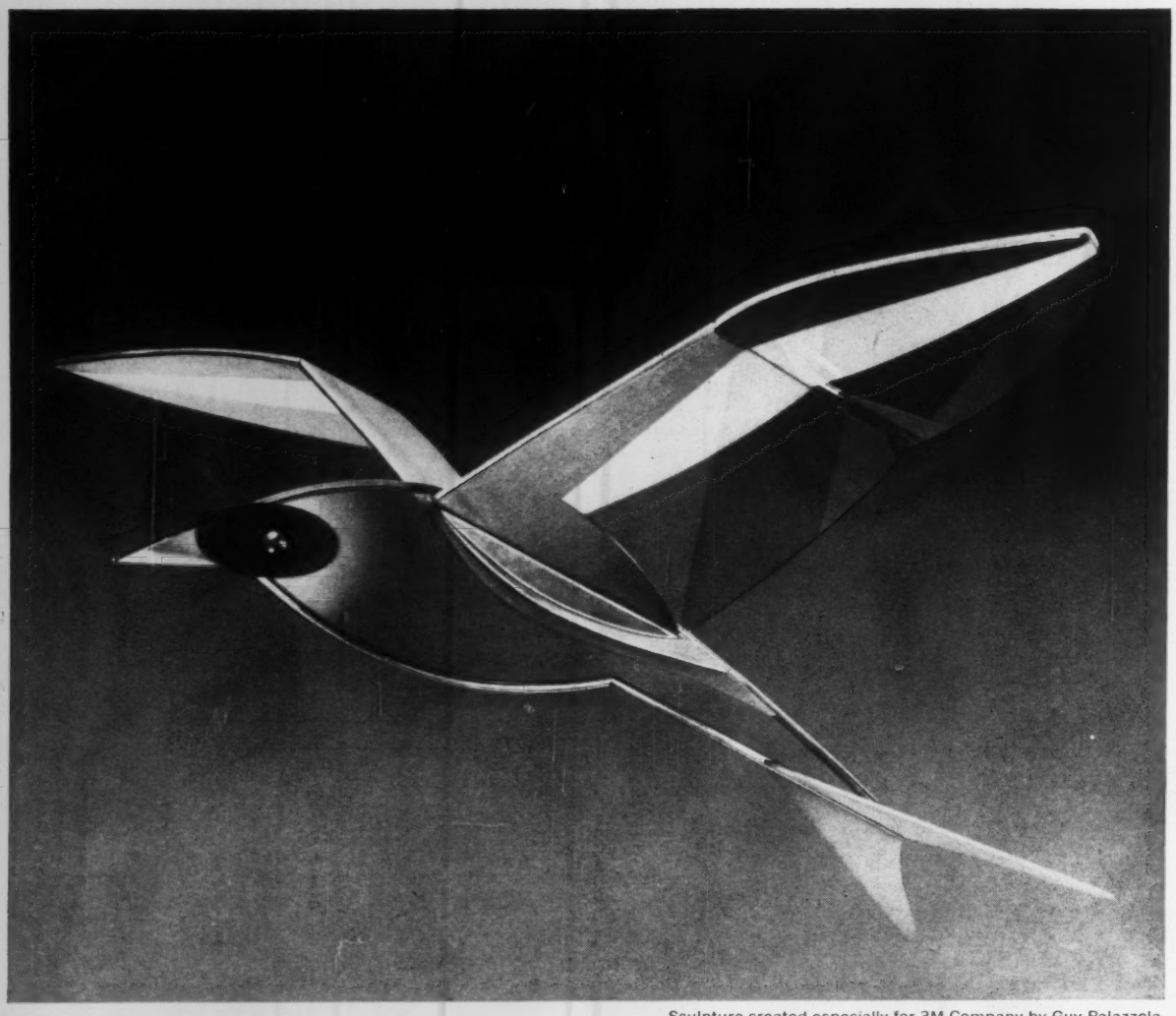
Parts which have been infiltrated may be oil hardened for those applications requiring extremely high strength, hardness, and wear characteristics.

Our engineers are available to consult with you at any time and place about new developments and new applications for this basic process. Ask them to explain to you the economies of complex parts made from sintered metals.

DELCO MORAINE

Division of General Motors, Dayton, Ohio

For more information, turn to Reader Service card, circle No. 422



Sculpture created especially for 3M Company by Guy Palazzola

FEATHER-LIGHT...

3M Adhesives help take pounds off today's metalworking products

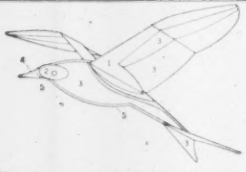
Reducing dead weight can give a product extra sales advantages . . . make it easier to handle and assemble . . . lower shipping and production costs. The answer: Fabricate with 3M Industrial Adhesives and save weight without sacrificing strength.

In fact, 3M Adhesives often substantially increase the strength of an assembly by distributing stresses evenly over a wide area, making lightweight, high-strength designs possible. And without mechanical fasteners that lower the integrity of the material and cause stress points that tear, fabricators can substitute lighter gauge materials.

For example, 3M Adhesive EC-1357—only one of a complete line of strong, general purpose industrial adhesives—finds wide application in products requiring strength and light weight. It is used in the bonding of metal frames to veneered plywood . . . in honeycomb construction for table tops . . . in sandwich-type wall panels, where it bonds porcelain enameled steel to an expanded glass core.

Backed by a quarter century of research, 3M Technical Service is solving fabrication problems for leading manufacturers in various industries. For an accurate appraisal of how an adhesive can add strength, light weight, production economy, and greater design freedom to your process or product, look first to 3M. Write AC&S Division, 3M Company, Department SBHH-111, St. Paul 6, Minnesota.

© 3M Co., 1961



What do you want to bond to what?

The Bird is fabricated of these materials and bonded with a variety of 3M Adhesives:

1. Stainless Steel 2. Wood 3. Plastic 4. Glass 5. Brass.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

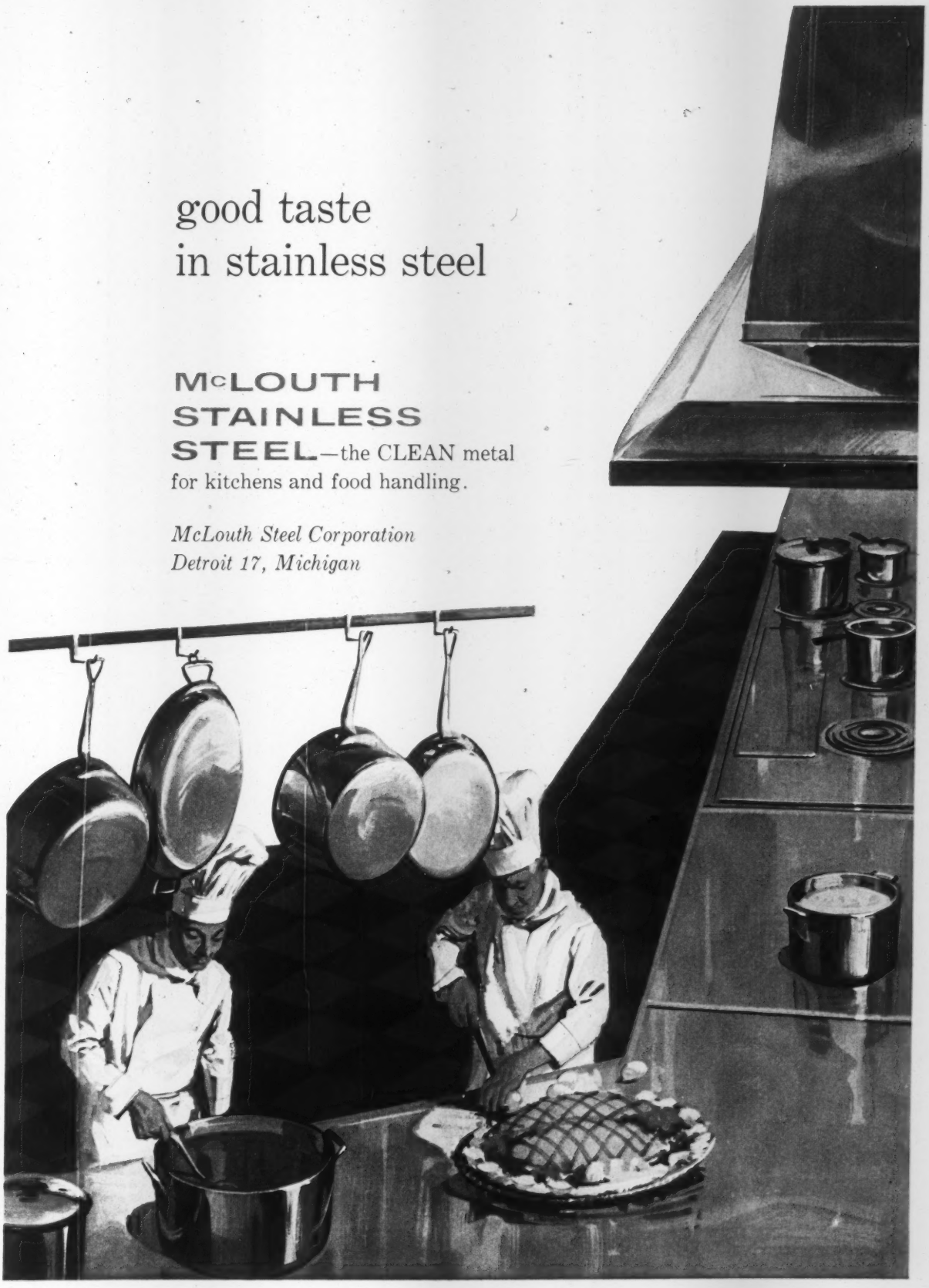
For more information, turn to Reader Service card, circle No. 391

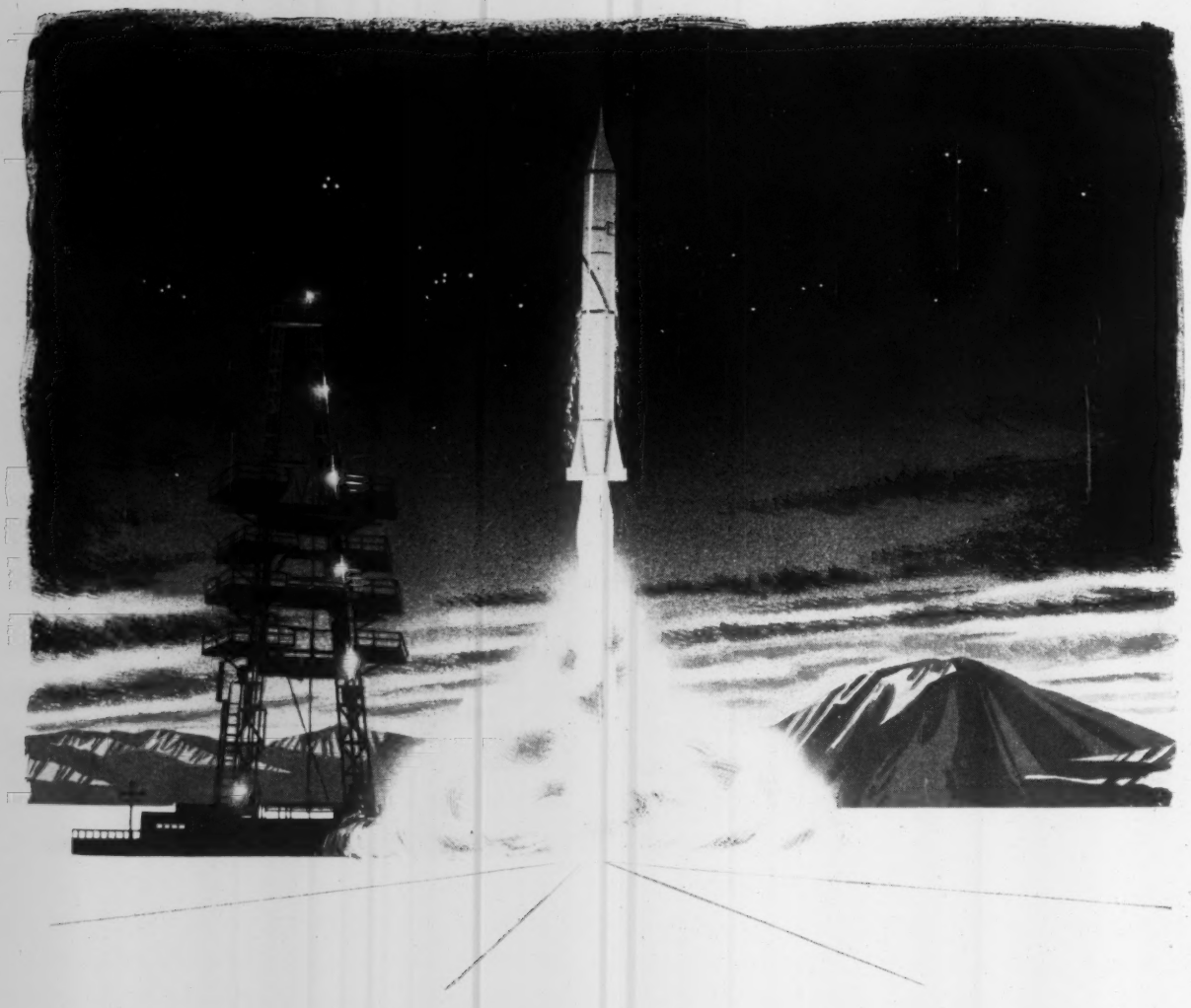
For more information, circle No. 461 ➤

good taste
in stainless steel

McLOUTH STAINLESS STEEL—the CLEAN metal for kitchens and food handling.

McLouth Steel Corporation
Detroit 17, Michigan





R/M ASBESTOS-PHENOLICS

hottest weight-savers for hot missile parts

Pound for pound, R/M asbestos-phenolic missile parts give you far greater strength and stability at extreme temperatures than metals.

This amazing family of asbestos reinforced plastics retain their good mechanical properties for the time-temperature relationship required for missile parts. At elevated temperatures where other materials fail, asbestos-phenolics made by R/M provide superior strength retention and controlled ablation.

R/M asbestos-phenolics are noted for their low thermal conductivity and diffusivity. Because they are based on extra-long spinning grade asbestos fibers, they assure high strength-to-weight ratios, superior shock resistance, and uniform ablation.

Felts, mats and molding compounds are available from R/M for prompt shipment in production quantities. They are backed by comprehensive technical data and know-how. Write for information and engineering help.

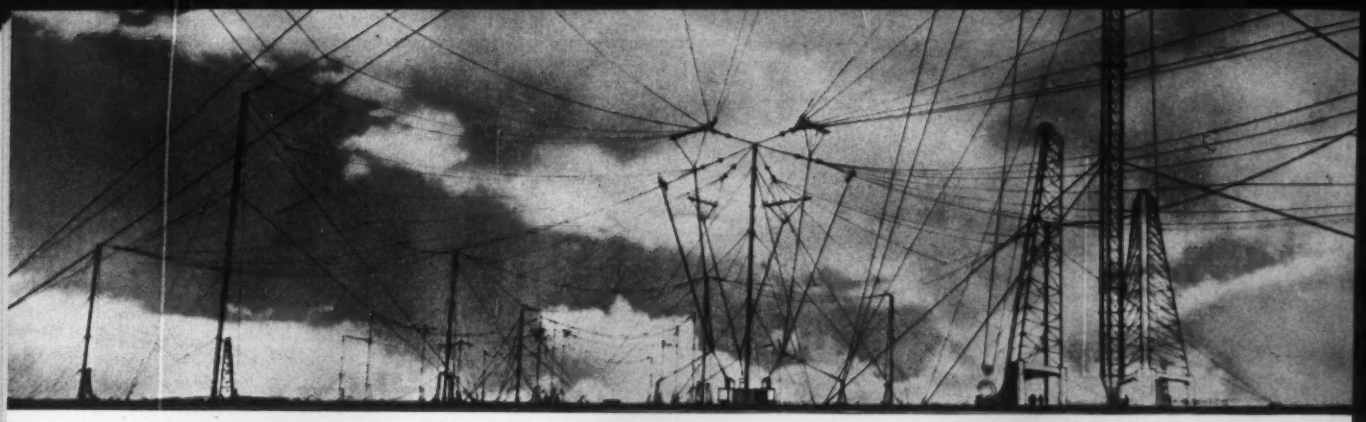
Nozzle of R/M Style 150RPD Pyrotex® molding compound.

RAYBESTOS-MANHATTAN, INC.

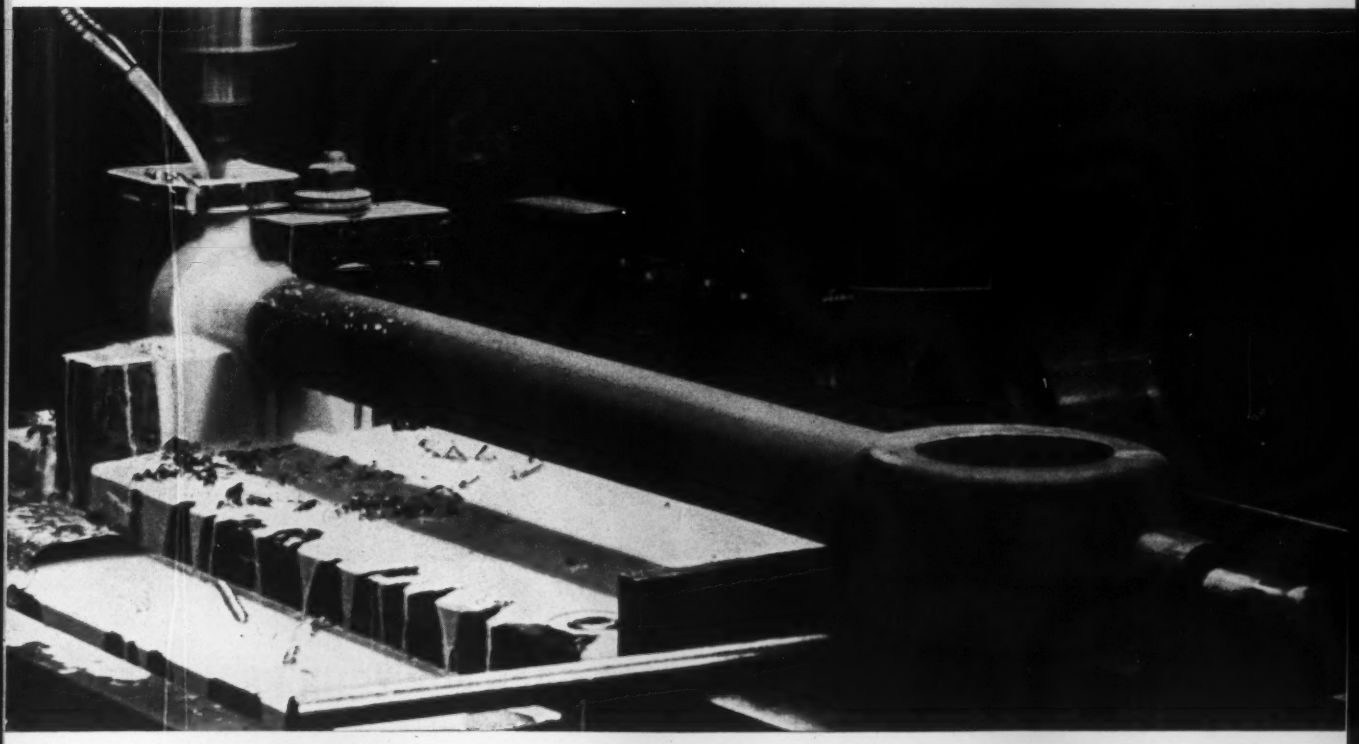
Reinforced Plastics Department, Manheim, Pa.

SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED METAL

For more information, turn to Reader Service card, circle No. 394



World's largest radio antenna contains 800 special Bethlehem eye-bolts



Husky eye-bolts, 800 of them weighing 75 lb each, are insulator-chain links guying the antenna of the most powerful radio station ever built. This specially engineered eye-bolt is typical of the special fasteners which Bethlehem manufactures in a wide variety.

This gigantic broadcasting station, located near Machias Bay on Maine's rock-bound coast, permits the U.S. Navy to reach submerged submarines half-way 'round the world.

Whether you need a tiny bolt with a special head . . . or a large-size "special" made to precise specifications, the chances are good that we can make it at an attractive price.

Just send a drawing or sketch of what you need, with a description of its application. Write or call the nearest Bethlehem sales office. Or get in touch with us at Bethlehem, Pa.

Steel *for Strength . . . Economy . . . Versatility*

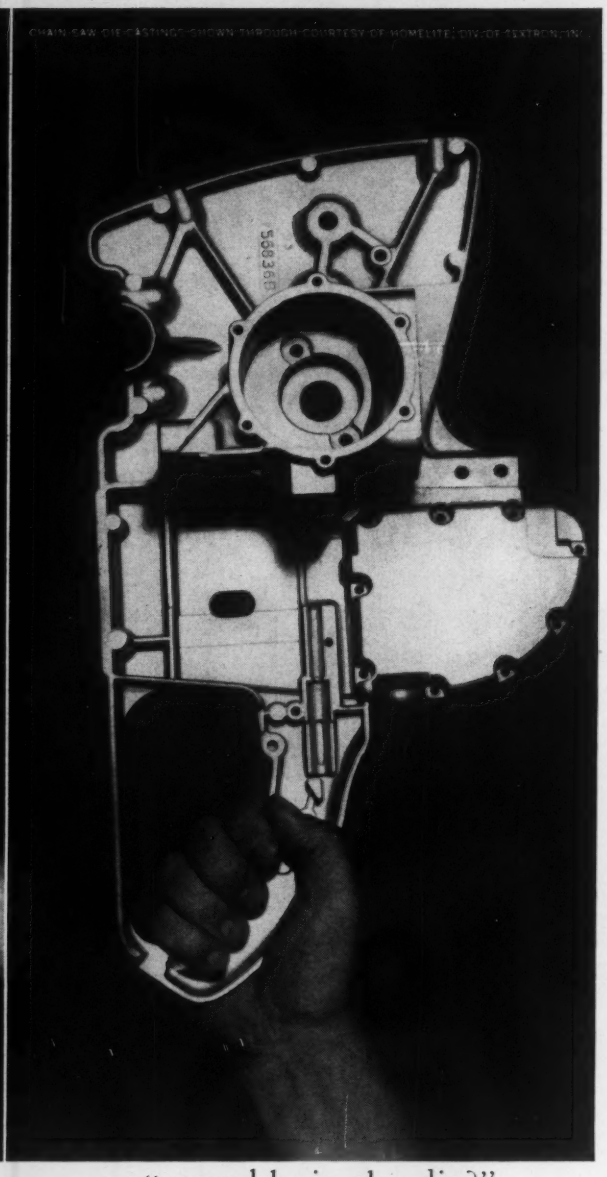
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 407

Multi-part assembly...



CHAIN SAW DIE CASTINGS SHOWN THROUGH COURTESY OF HOMELITE, DIV. OF TEXTRON, INC.

or "assembly in the die?"

WHICH PROVIDES THE COST-CUTTING EDGE FOR YOUR PRODUCT?

If your product involves the assembly of two or more related metal parts, the chances are you can make important savings and a better product by having assembly "done in the die." Skilled one-piece die casting by Doehler-Jarvis cuts tooling and metal costs to the bone . . . saves you time and money at every assembling and joining stage. You save on rejects, too — in one-piece die casting, there are no such things as mismated parts. We call it UNITATION . . . the unique Doehler-Jarvis combination of unitizing and automation that produces the part you want in a single, strong casting. To learn how you can benefit from UNITATION, why not let an experienced D-J engineer take a hard analytical look at your cast, formed or assembled metal parts. His suggestions may save you thousands of dollars. Write or call.

DOEHLER-JARVIS
DIVISION OF NATIONAL LEAD COMPANY

GENERAL OFFICES: TOLEDO 1, OHIO. PLANTS AND SALES OFFICES: TOLEDO, OHIO; GRAND RAPIDS, MICHIGAN; POTTSTOWN, PENNSYLVANIA; BATAVIA, NEW YORK. IN CANADA: BARBER DIE CASTING CO., LTD., HAMILTON, ONTARIO. IN BRAZIL: INDUSTRIAS DOEHLER DO BRASIL, S. A., SAO BERNARDO DO CAMPO, SAO PAULO. IN ARGENTINA: DOEHLER ARGENTINA, S. A., BUENOS AIRES. IN GREAT BRITAIN: METAL CASTINGS (DOEHLER, LTD., WORCESTER, ENGLAND.

For more information, turn to Reader Service card, circle No. 467

An example of Avisco Rayons in Industry

What do you want to filter better?

The new Avisco® rayons have physical, mechanical and chemical properties of importance to the filtration field.

Being man-made, Avisco rayon fibers can be held precisely to the lengths and diameters desired. This facilitates processing—wet or dry—and improves control of porosity, stiffness and bulk of the filter mat.

Avisco rayon has good resistance to most gases, most of the common organic compounds, and inorganic materials with the major exceptions of concentrated mineral acids, hot dilute mineral acids, concentrated caustic alkalies and certain powerful oxidizing agents.

Write for Avisco Technical Bulletin G-15, containing properties, applications and samples of filter webs made of Avisco rayon. Use the Quick Reply Coupon at right.

QUICK REPLY COUPON 9-4

Industrial Merchandising Division
American Viscose Corporation
350 Fifth Avenue, New York 1, N.Y.

Please contact me about Avisco Rayons for use in the following application:_____

Name_____

Company_____

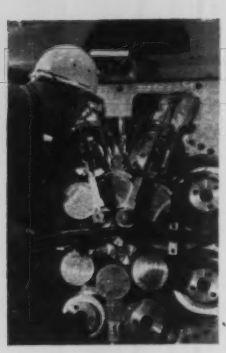
Address_____

City_____ Zone____ State_____

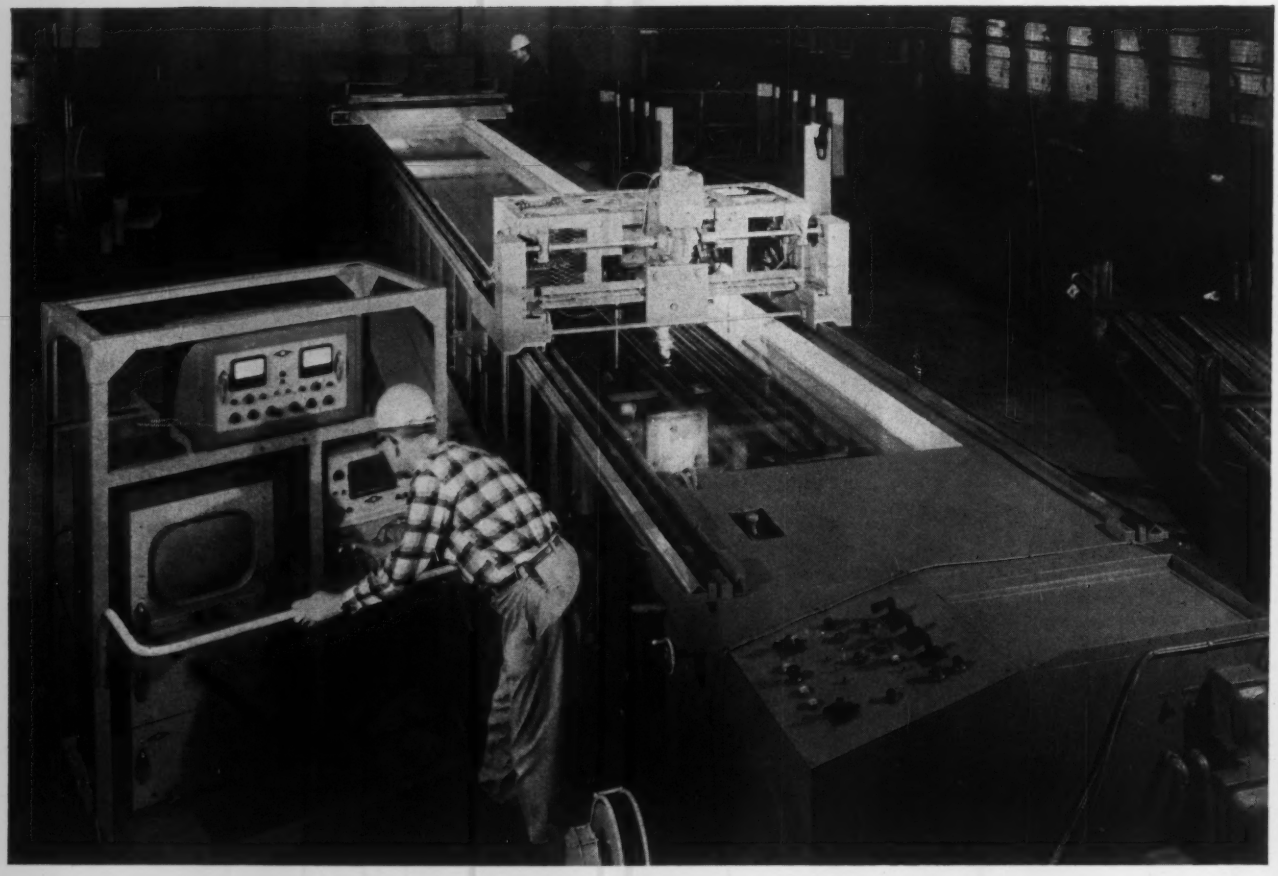
AVISCO® RAYON

AMERICAN VISCOSE CORPORATION, 350 Fifth Avenue, New York 1, N. Y.

For more information, turn to Reader Service card, circle No. 342



What Armco's advanced array and inspection equipment



Bells ring, lights flash and pictures appear on the TV screen when stainless steel bars or billets with subsurface defects are dunked in Armco's "electronic bathtub." It's part of Armco's ultra-modern stainless production and inspection equipment, among the most advanced in the nation.

New steels are born at Armco

# of Stainless Steel production means to you

Wider selection plus high quality you can count on in stainless steel sheets, strip, bars and wire. That's what Armco's modern stainless production and inspection facilities offer you.

Wider Selection—These, for example, are a few recent additions to Armco's already great variety of stainless steels: Continuous mill produced sheets up to 48 inches wide; cold-rolled and temper-rolled plates up to 72 inches wide and 216 inches long; range in bright annealed strip increased to 12 different grades.

High Quality You Can Count On—At every production step, Armco uses the newest special inspection and control methods to assure you of cost-saving uniformity during fabrication. In Armco Stainless Bars, for example, *controlled uniformity* means fewer tool adjustments and costly rejects in your shop.

For durability, strength, economy.

This is only part of the story, but we'll be happy to give you complete information on Armco's full range of stainless steels. Write us or contact a distributor of Armco Stainless Steels listed on this page. **Armco Division, Armco Steel Corporation, 2071 Curtis Street, Middletown, Ohio.**

ARMCO **Armco Division**

GET SELECTION AND QUALITY IN ARMCO STAINLESS FROM THESE STEEL SERVICE CENTERS

(A) Sheets, Strip and Plates (B) Bars and Wire

AMERICAN STEEL & ALUMINUM CORP. (AB)
Hartford, Conn.

AMERICAN STEEL & ALUMINUM CORP. OF MASS. (AB)
Cambridge, Mass.

BROWN-WALES COMPANY (AB)
Cambridge, Mass.—Auburn, Maine—Worcester, Mass.

CENTRAL STEEL & WIRE COMPANY (AB)
Chicago, Ill.—Cincinnati—Detroit—Milwaukee

CHICAGO STEEL SERVICE COMPANY (AB)
Chicago, Ill.

CLEVELAND TOOL & SUPPLY COMPANY (B)
Cleveland, Ohio

THE CONGDON AND CARPENTER COMPANY (AB)
Providence, R. I.—Fall River, Mass.—Natick, Mass.

C. A. CROSTA, INC. (A)
Denver, Colo.

DUCOMMUN METALS & SUPPLY COMPANY (AB)
Los Angeles, Calif.—Berkeley—Phoenix—San Diego—Seattle

EDGCOMB STEEL & ALUMINUM CORP. (AB)
Hillside, N. J.

EDGCOMB STEEL COMPANY (AB)
Philadelphia, Pa.—Charlotte, N. C.—Greensboro, N. C.—York, Pa.

ESCO CORPORATION (AB)
Portland, Oregon—Denver—Emeryville, Calif.—Eugene, Oregon—Honolulu—Los Angeles—Seattle—Spokane—Vancouver, B. C.

PETER A. FRASSE & COMPANY, INC. (AB)
New York, N. Y.—Buffalo—Hartford—Lyndhurst, N. J.—Philadelphia—Syracuse

FIRTH BROWN STEELS LTD. (AB)
Montreal, P. Q.—Toronto

GATE CITY STEEL, INC.—OMAHA (AB)
Omaha, Nebr.—Columbus, Nebr.

INDUSTRIAL STAINLESS STEELS, INC. (B)
Cambridge, Mass.—Buffalo, N. Y.

EARLE M. JORGENSEN COMPANY (AB)
Los Angeles, Calif.—Dallas—Denver—Honolulu—Houston—Oakland—Phoenix—Seattle—Tulsa—Wichita

MAPES & SPROWL STEEL COMPANY (AB)
Union, N. J.

METAL GOODS CORPORATION (AB)
St. Louis, Mo.—Dallas—Denver—Houston—Memphis—New Orleans—N. Kansas City, Mo.—Tulsa—Wichita

MONCRIEF-LENOIR MFG. COMPANY (AB)
Houston, Texas—Dallas—Harlingen—Lubbock—San Antonio—Temple

MORRISON STEEL COMPANY (AB)
New Brunswick, N. J.

THE ORLEANS STEEL PRODUCTS COMPANY, INC. (A)
New Orleans, La.

WILLIAM M. ORR COMPANY, INC. (AB)
Pittsburgh, Pa.

PAPER-CALMENSON & COMPANY (A)
St. Paul, Minn.

SEABOARD STEEL & IRON CORP. (B)
Baltimore, Md.

SENECA STEEL SERVICE, INC. (AB)
Buffalo, N. Y.—Jamestown, N. Y.

SOUTHER STEEL & ALUMINUM COMPANY (A)
St. Louis, Mo.

J. M. TULL METAL & SUPPLY CO., INC. (AB)
Atlanta, Ga.—Birmingham—Greenville, S. C.—Jacksonville—Miami—Tampa

VIKING STEEL COMPANY (AB)
Cleveland, Ohio

VORYS BROTHERS, INC. (AB)
Columbus, Ohio

YORK CORRUGATING COMPANY (A)
York, Pa.—Washington, D. C.

For more information, turn to Reader Service card, circle No. 480

STOKES invites you to investigate the many marketing advantages of offering your product in tablet form. By the simple device of tabletting your product in a distinctive shape, for example, you can establish strong product identity . . . even in a highly competitive market. Since tablets are more compact than powders, package-size requirements are reduced. The savings realized from this reduction in size can be put to work "glamorizing" the package.

Tablets also have the advantage of built-in measurement. With a tablet detergent, for example, busy housewives do not have to waste time fumbling with measuring cups. A few tablets and the family wash is ready to go. Kiddies can also make their own soft drinks with a single, no-mess effervescent tablet.

And this is just a sampling of the many exciting marketing possibilities offered by modern high-speed tabletting. There are many production advantages, too. To get more information, contact your nearest Stokes representative. If you desire, we will gladly test run your product in the Stokes Laboratory and make detailed tabletting recommendations. Tabletting Press Division, F. J. Stokes Corporation, 5500 Tabor Road, Philadelphia 20, Pennsylvania.

detergents
soft drinks
coffee
bleach
bath salts
insecticides
water treatment tablets
concentrated foods

think tablets

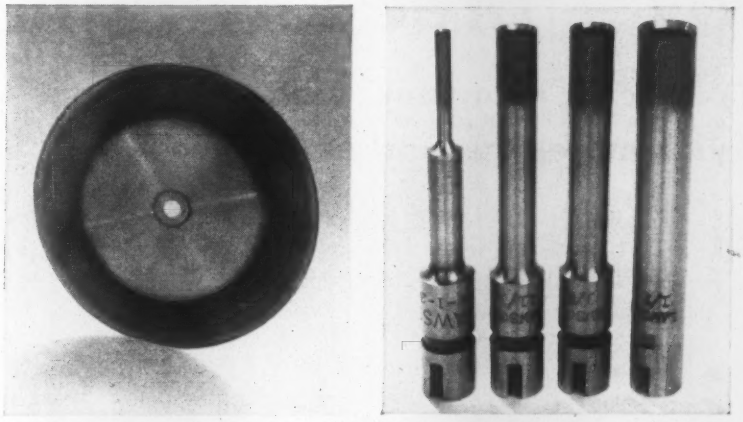
Put **STOKES** 50 years of tabletting experience to work for YOU!

For more information, turn to Reader Service card, circle No. 403

Linde Coatings & materials News

LINDE COMPANY, DIVISION OF UNION CARBIDE CORPORATION

Long wear for precision cutting parts now comes in thin coatings—.001" thick



Two important industrial cutting tools whose working lives have been multiplied by LINDE Flame-Plating tungsten carbide coatings: Rubber skiving knives (l.) and paper drills.

SUPER-THIN coatings of tungsten carbide and aluminum oxide—in the .00075" to .002" range of thickness—now keep many industrial cutting surfaces on the job many times longer than previously, yet preserve the precision fit needed for optimum cutting. The result: important savings in downtime and operating costs.

These tough, long-life precision coatings are applied by LINDE's Flame-Plating process, which "blasts" molten particles of tungsten carbide onto specified areas of wearing surfaces until the particles are built up to the desired degree of thickness.

Typical examples of longer wear

Because their cutting surfaces are Flame-Plated with tungsten carbide coating, rubber skiving knives that formerly required resharpening after every shift now stay in use 15 times longer. The knives also have the advantage of a self-sharpening effect. As the softer steel base wears more rapidly than the hard, tungsten carbide coating, a sharp edge is always presented to the material being cut.

Tungsten carbide coating enables serrated knives used in cutting plastic sheeting to process three times as much material before the first re-sharpening is necessary.

A coating of .001" thickness on the inside cutting surface of surgical shears has reduced their rate of wear by as much as 33 percent.

Flame-Plating proved so revolutionary for household cutlery that the manufacturer built his merchandising theme around *"The Greatest Development in 2000 Years of Cutlery Making—a Cutting Edge of Tungsten Carbide."*

Solves many wear problems

Tungsten carbide coatings of microinches thickness are equally effective wherever metal parts or working surfaces are exposed to abrasion, galling, erosion, fretting, corrosion, or high-temperature wear. Coatings are applied by the LINDE's 6,000-degree Flame-Plating process without distortion of the work piece or changes in properties of base metals.

For full information on Flame-Plating for your particular application, check and mail the coupon below.

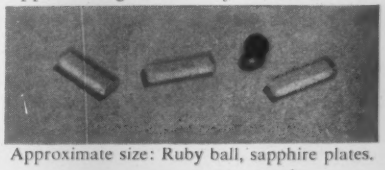
Need to production-polish tungsten carbide surfaces?

It's easy with LINDE metallographic production-polishing aluminas—available in grades for three types of finishing: For high stock removal, 1 micron C; for moderate stock removal and ¼ rms finish, 0.3 micron A; for super polish, 0.05 micron B.

LINDE has developed special techniques for production-polishing of semiconductors and soft metals (such as brass), also new ideas for production-polishing hard metals, including micrometer anvils, hardened bearing races, routine metallographic samples. Get help with polishing techniques to meet your requirements. Send coupon below.

Jet planes landed by ruby-against-sapphire wear pads

In the automatic landing computer of a modern jet interceptor, a tiny ruby ball held to tolerances of 30 millionths oscillates against a synthetic sapphire plate flat to 1/10 light band, as a reference plate for a computer to translate radar approach signals into hydraulic actions.



Approximate size: Ruby ball, sapphire plates.

A similar wear surface bears on the cam head. Certain fly wheel governors also have sapphire wear surfaces.

This 70,000 to 300,000 psi LINDE material has a hardness second only to diamond, unlubricated static friction coefficient of .18, and dynamic of .08 against itself in moderate loads. It is economically suited for wear applications such as gage points, textile guides, optical inspection flats, and flow valves. Send coupon for information.

CHECK—CLIP COUPON—ATTACH TO BUSINESS LETTERHEAD

Linde Company
270 Park Avenue
New York 17, N. Y.

Please send data on the items checked:

- ☐ LINDE Flame-Plating Process
- ☐ LINDE Alumina Abrasive Powders
- ☐ LINDE Synthetic Sapphire & Ruby

UNION CARBIDE

LINDE COMPANY

"Linde" and "Union Carbide" are registered trademarks of Union Carbide Corporation

For more information, turn to Reader Service card, circle No. 464

HERCULES **Plastics Hi-Lites**

Pro-fax® proves precisely right

A must plastic for many new uses, Pro-fax always provides the most plastic, too

Because it offers advantages never before available in a thermoplastic, Pro-fax polypropylene has become a "must" for many new uses. But not for exactly the same reasons in every instance. Versatile Pro-fax has many important features unique in its price-property class, and often just a single one of them is ample justification for its usage. Sometimes heat and chemical resistance are the all-important "musts." Again, the economies made possible by the built-in Pro-fax hinge have been foremost in prompting its selection. Its light weight and resilience have on many occasions been prime reasons for specifying Pro-fax.

Whatever the "must," Pro-fax invariably also provides the *most* in a modern construction material. Lightest of all plastics, it yields the most plastic product per pound. Its many innate plus features, in terms of properties, processability and cost, always add up to big value in functionality... merchandising appeal .. and consumer satisfaction.

Pro-fax is in the picture when heat resistance is a "must"

Resistance to heat from the projector light made Pro-fax a "must" for "Duo-jector." This new magnifier-projector for slides, artwork, photos, coins and stamps has a host of other plus features thanks to Pro-fax: compact, attractively styled, readily portable—since it's made with the lightest of all plastics—Duo-jector is virtually unbreakable, with a rich, colorful finish that is immune to staining and will withstand both use and abuse.

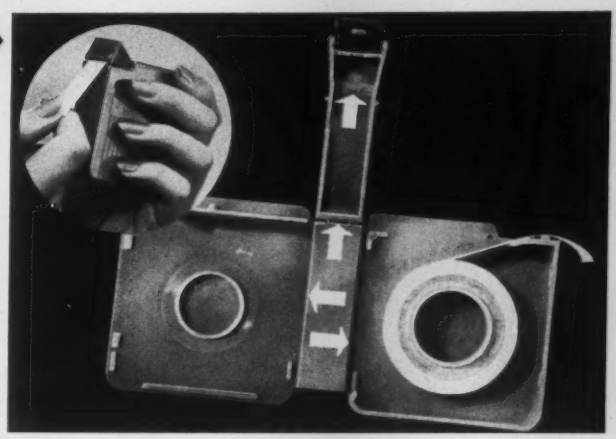
Molded by Como Plastics, Columbus, Indiana, for Rainbow Crafts, Inc., Cincinnati, Ohio.

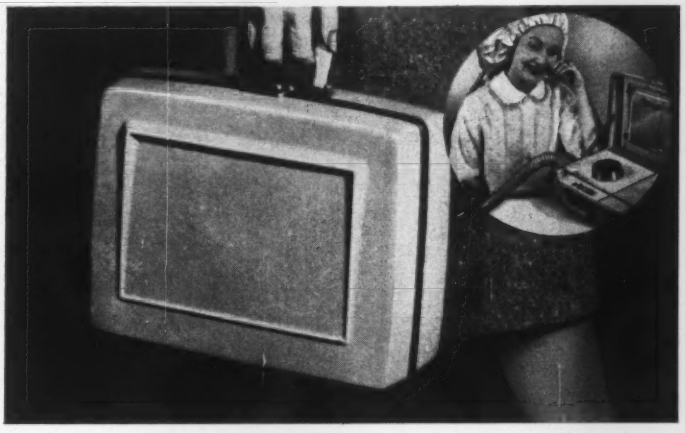
Pro-fax hinges dispense with assembly costs

Pro-fax was a "must" in this unique dispenser-package for Permacel's RIBBON DOPE* Thread Sealant, a new sealer designed for use on threaded pipe joints. Four integrally molded hinges are combined in a single molded part which opens to accommodate a roll of RIBBON DOPE, then folds and locks together to make a lightweight compact carrier. A snap-in blade cuts tape to any desired length, and the handy unit can be tucked in pocket or tool box, stored in any convenient place, or kept available on the worktable. When product success hinges on functionality plus low cost, Pro-fax provides the *most* plastic for the job.

*Trademark of Permacel

Molded by Pyro Plastics Corp., Union, N. J., for Permacel, New Brunswick, N. J.





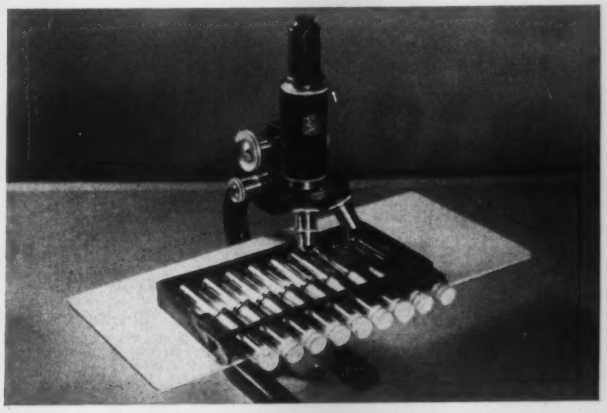
DOMINION makes a case for Pro-fax in portable home appliances

All of the advantages of Pro-fax which make it ideal for luggage—light weight, resilience, resistance to scuffing and staining—were needed in the case for Dominion Electric's new hair dryer. But UL listing was required, too. Dominion achieved this by the use of an intumescent coating, applied to the interior surface of this handsome injection-molded carrier. Result: A revolutionary new appliance, a veritable portable beauty salon, easily moved, usable anywhere.

Molded by Compro Company, Canton, Ohio; for Dominion Electric Corp., Mansfield, Ohio.

Many "musts" make Pro-fax the most

The combination of properties available in Pro-fax made this radical new concept in laboratory equipment a reality. Six of these molded "drawers," each holding nine culture tubes, nest in a compact case which permits handling 54 tubes at one time. They replace a cumbersome metal rack which required individual handling of each tube under the microscope and during subsequent cleaning and sterilizing. Pro-fax was a "must" for the resilient retainer rings which anchor test tubes firmly in place so that a full drawer can be studied, washed, and steam-autoclaved without removal. Pro-fax was a "must," too, for the built-in hinge catch on each drawer, designed to hold it in the six-drawer case. All these many "musts" have made Pro-fax the *most* plastic for a variety of new laboratory-ware applications, including test tubes, beakers, and a number of measuring devices.



Molded by Philadelphia Plastics and Manufacturing Co., Phila., Pa., for Advance Scientific Corp., Phila., Pa.

HERCULES POWDER COMPANY

Polymers Department
Hercules Tower, 910 Market Street, Wilmington 99, Delaware

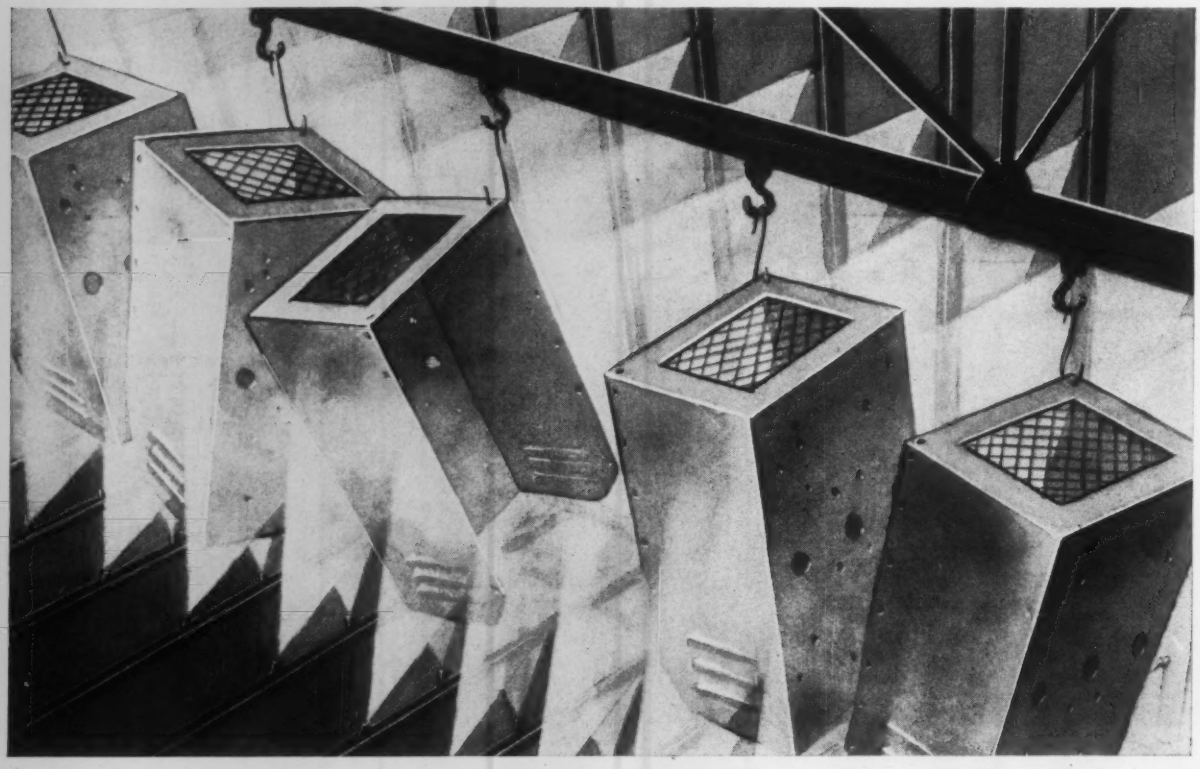
QP61-3

For more information, turn to Reader Service card, circle No. 475

For tough steel cleaning jobs

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 FIELD SERVICE MEN • OVER 160 MATERIALS



New acid cleaner Oakite 86 gives fast smut removal . . . good paint grip

Shop smuts on steel parts disappear fast with Oakite 86 in the washing machine. A superior acid detergent, it removes all kinds of soils efficiently—really goes to work on heavily smutted steel. In addition, it forms a conversion coating on steel surfaces to give a good grip on subsequent paint coats . . . helps inhibit corrosion.

Oakite 86 also works well when aluminum, zinc, brass and terneplate pass through the washer.

And it is just the latest in a complete line of Oakite materials for spray washing machines. Others include products for high-pressure spraying, for rapid cleaning, for heavy-duty cleaning, for low-heat cleaning, for conversion coatings. Ask the Oakite man which one will work best with your machines, your metals, your specific jobs. Or, write for FREE bulletin. Oakite Products, Inc., 26 Rector Street, New York 6, N. Y.

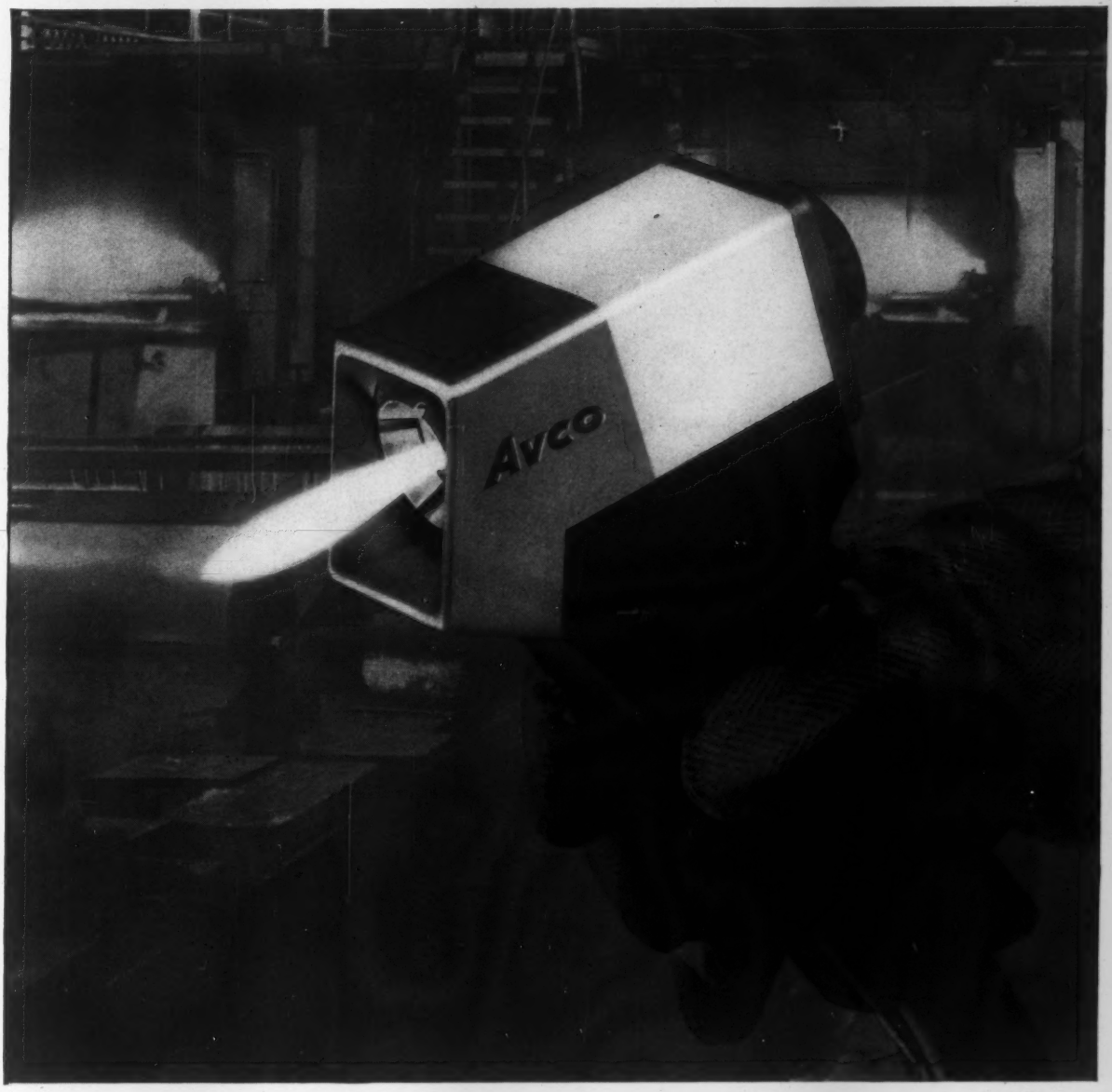
it PAYS to ask Oakite

OAKITE

SCIENCE

over 50 Est. 1909 years' leadership in industrial cleaning

For more information, turn to Reader Service card, circle No. 424



Avco puts the PlasmaGun to work—in your plant

This Avco PlasmaGun spray-coats metals, ceramics and refractories with a thickness, density and bond strength never before possible—right on your production line.

It sprays uniformly without clots or streamers at roughly half the cost of other plasma equipment. And you can save up to 30% over conventional spray-coating—even more when fabricating free-standing parts from materials such as tungsten.

The Avco PlasmaGun takes powders previously too fine for other plasma equipment. The cathode is adjustable, too, for convenience and economy. (No need to switch cathodes each time you change powders.)

The cost? Lower than you think. It can pay for itself on the first job. Maintenance? Easiest of any gun in the field. (The PlasmaGun assembles with only 4 bolts!) Warranties? On all parts, for six months. (Another exclusive Avco feature.)

AVCO
Research & Advanced Development division

Avco's special PlasmaGun booklet describes the complete system. Send for your free copy right now!

AVCO Research and
Advanced Development Division
Dept. 11-5, Wilmington, Mass.

Please send free information about new PlasmaGun system.

Name_____

Organization_____

Address_____

City_____ Zone____ State_____

Title_____

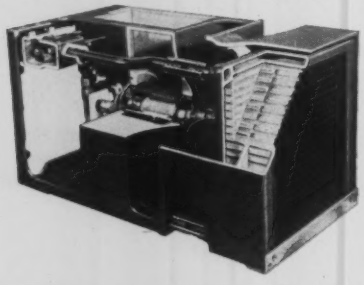
For more information, turn to Reader Service card, circle No. 486

THE HEAT IS OFF THE B-52

General Electric silicone dielectric fluids keep electronic gear running cool and efficiently – indefinitely

We've taken the heat out of the B-52. We've done the same for the B-47, B-57, and B-66. We can do the same for you.

Shown here is the HALLICRAFTERS Company heat exchanger, HD-406, now being used to cool electronic counter measures equipment in all of the above Air Force bombers.



G-E silicone dielectric fluid SF-97 is used as a coolant and dielectric in this equipment. This coolant has excellent electrical properties, and eliminates pressurization requirements at high altitudes.

SF-97 also maintains *consistent* viscosity: requires minimum pumping power. It operates over a wide temperature range, (down to −65°F), cooling reliably and efficiently. Possesses excellent thermal and oxidative stability.

G-E silicone dielectric fluids are used in capacitors, pulse transformers, in air-borne and land-based radar units, and in many systems where heat transfer and dielectric properties are necessary.

If you need the heat taken off your electronic components, get the full story on G-E silicone dielectric fluids. Write: General Electric Company, Silicone Products Department, Section B1162, Waterford, N. Y.

GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 348

NEW 'ENPLATE' chemical plating baths plate without electric current

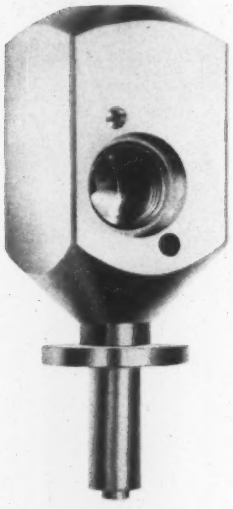


PLATE HARD NICKEL
OF UNIFORM THICKNESS ALL OVER

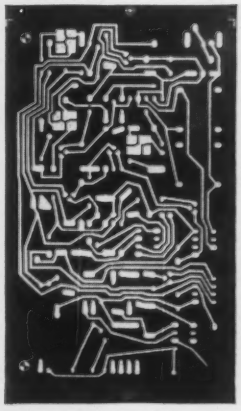


PLATE COPPER ON PRINTED
CIRCUITS, PLASTICS, CERAMICS, METALS

COMPLETE 'ENPLATE' PROCESSES AVAILABLE FOR PLATING ON MORE THAN 50 MATERIALS— FROM ALUMINUM TO VINYL

Plastics, printed circuits, rubber, glass, ceramics, ferrites, other non-conductors and semi-conductors, metals. These are among more than 50 materials you can now plate efficiently at low cost with Enthone's new line of 'Enplate' electroless nickel, copper and silver plating products and processes.

For example, 'Enplate' Ni-410 deposits a hard, wear-resistant, nickel-phosphorous coating of uniform thickness on the most complex parts. Corrosion resistance is better than electroplated nickel. Brass housing illustrated above has same thickness of 'Enplate' nickel in blind holes and screw threads as on outer surfaces and edges. 'Enplate' CU-400 is excellent for rapid application of a thin film of copper on non-conductor surfaces. Plastic surfaces, such as thru-holes in printed circuit board shown, can be made conductive for subsquent electro-plating.

'Enplate' chemical plating baths are highly purified, ready-to-use liquid concentrates. Just add to water to make instantly usable chemical plating solutions. For guidance on your best chemical plating cycle and on proper cleaning and activation procedures, write today for your copy of the new 'Enplate' brochure. Enthone Incorporated, 442 Elm Street, New Haven 8, Conn.

ANOTHER PRODUCT OF *Enthonics* RESEARCH

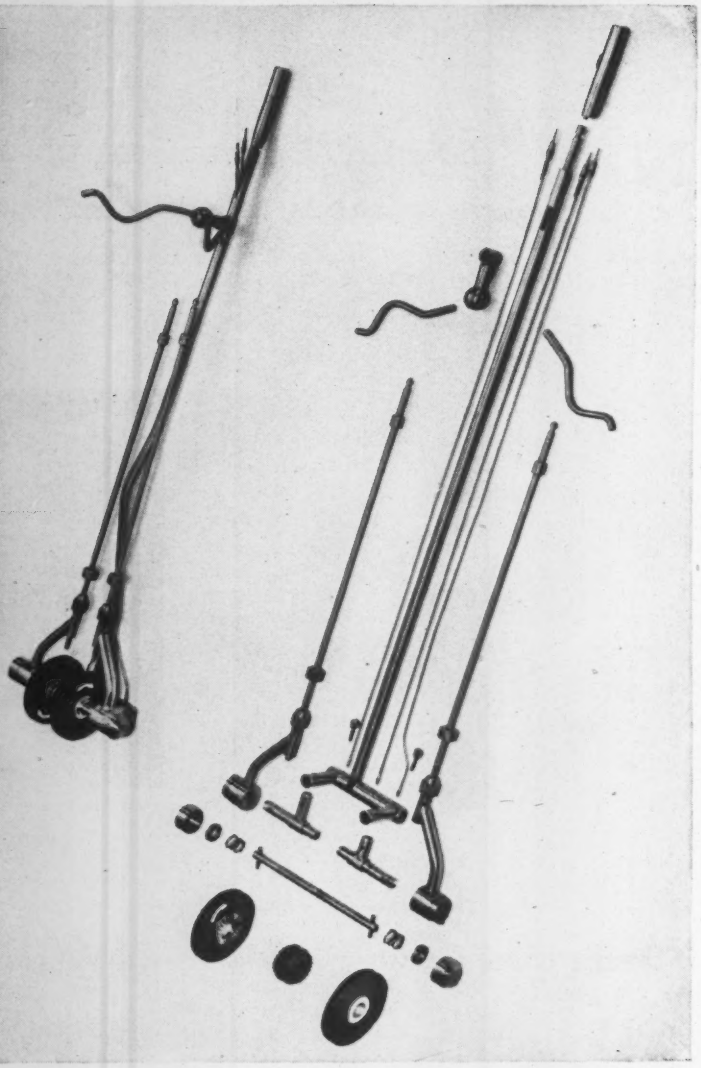
ENTHONE *A Subsidiary of American Smelting and Refining Company* ASARCO

CHEMICAL PLATING

For more information, turn to Reader Service card, circle No. 428

HERE'S HOW STILL ANOTHER MANUFACTURER JOINS STAINLESS STEEL TUBING:

He uses Handy & Harman's BRAZE 630



He's one of many manufacturers and fabricators who have found—to their lasting satisfaction—that Handy & Harman silver alloy brazing is the final answer to stainless steel joining problems.

Super-Donic Manufacturing Company, Atlanta, Georgia, manufactures "Dual Arm Transmissions" for the dental industry. Most everybody has—at one time or another—seen and/or felt this unit in operation.

It is fabricated of small diameter 304 and 316 stainless steel tubing and, in its assembled form, consists of some 17 separate brazed joints. Joints must be strong, corrosion resistant and neat-appearing.

Each of the 17 joints is hand-torch brazed with Handy & Harman BRAZE 630 wire and HANDY FLUX TYPE B-1. There's no question that this is a unique application. There's no question, either, that the application is stainless steel. The ease and economy with which this manufacturer solves his problems can be just as readily applied to *your* stainless steel joining problems.

Strength, production speed, electrical and thermal conductivity, gas and liquid tightness and low cost are *natural* benefits of silver alloy brazing. We think it worth your while to learn more about this remarkable metal-joining method—we'll be glad to send you any information you ask for. Handy & Harman, 850 Third Ave., New York 22, N. Y.

FOR A GOOD START: BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits . . . includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 850 Third Ave., New York 22, N. Y.

DISTRIBUTORS IN PRINCIPAL CITIES

Offices and Plants
Bridgeport, Conn.
Chicago, Ill.
Cleveland, Ohio
Dallas, Texas
Detroit, Mich.
Los Angeles, Calif.
New York, N. Y.
Providence, R. I.
San Francisco, Calif
Montreal, Canada
Toronto, Canada

For more information, turn to Reader Service card, circle No. 411

Nickel-base alloy No. 718 can be used for high temperature turbine forgings, recent experiments indicate. Originally developed for sheet metal applications, this material is said to have shown forgeability comparable to that of A-286 and other alloys used in hot rotating and structural members. In 100-hr tests at 1200 F the alloy exhibited a rupture strength of 95,000 to 100,000 psi.

Source: Wyman-Gordon Co., 105 Madison St., Worcester, Mass.

Two kinds of polypropylene team up for a strect sweeping job. Sweeper bristles made by combining a central core of oriented polypropylene fiber with an outer casing of extruded polypropylene are said to give more miles of sweeping than natural fibers used for this service. These materials were chosen for the strength of the central fiber, the abrasion resistance of the outer shell and the flexible spring characteristics of the composite bristle.

Source: Enjay Chemical Co., 15 W. 51 St., New York 19.

A 40,000-ft aerial tow cable is being tapered by electropolishing from 50 mils at one end to 20 at the other. The cable is being developed on the basis of a recent study which showed that electropolishing—the reverse of electroplating—did not significantly affect the strength properties of stainless steel wire or music wire. Since the load on a tow cable decreases toward the target end, a tapered cable will be stressed more evenly throughout its length, and the weight saved in tapering can be used to extend the length of the cable.

Source: Southern Research Inst., 2000 Ninth Ave. S., Birmingham, Ala.

Hydrogen-in-titanium standard samples for use in titanium quality control have been developed. The hydrogen content in titanium alloys, which impairs the usefulness of these materials, can be checked by analytical equipment calibrated with these samples. Reference materials containing three different levels of hydrogen are available. Work on oxygen and nitrogen-containing samples is in progress.

Source: National Bureau of Standards, Washington 25, D. C.

Square-cornered rubberized fabric bags for cushioning cargo are being manufactured. In addition to the square corners, another innovation is the bellows-like internal construction which controls bag expansion. These features are said to keep the inflatable dunnage bags in a rectangular shape under all working pressures. Eliminating round bag corners results in a larger gripping surface and a more uniform pressure applied to the cargo load.

Source: B. F. Goodrich Co., Akron, Ohio.

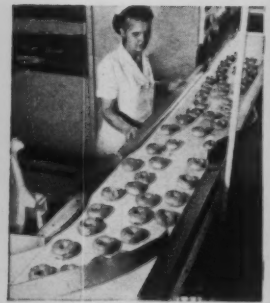
Dodecyl alcohol retards the propagation of fatigue cracks, according to recent tests performed on carbon steel, stainless steel, aluminum and a copper-beryllium alloy. A coating of this liquid reduced the rate of crack growth by factors ranging from 1.4 for stainless steel to 5.0 for the copper-beryllium alloy. These factors represent the increase in the number of stress cycles withstood from the time of crack formation to the time of fracture, which was 65 to 95% of total fatigue life. The coating appears to provide a barrier which deters harmful surface reactions with oxygen and water.

Source: National Bureau of Standards, Washington 25, D. C.

Tough, durable Mylar® cuts costs... improves product performance

For example, "Mylar"* polyester film gives many products extra resistance to chemicals, moisture and aging . . . lengthens their life. Today, "Mylar", with its high tensile strength in thin gauges, is improving the performance of products as different as wire and cable tapes and loose-leaf-sheet protectors.

Can this unique plastic film and products made with it help you? For more information on "Mylar", write the Du Pont Company, Film Dept., Room S-8, Wilmington 98, Delaware.



1. Conveyor belts of "Mylar" are easy to install, need fewer replacements, are easy to keep clean . . . cut "downtime," reduce costs.

2. Age-resistant recording tapes of "Mylar" won't ever dry out or get brittle . . . are highly stretch- and break-resistant . . . assure lasting fidelity.

3. Roll-back shelving of "Mylar" gets rid of retail stacking and stocking headaches. As shoppers remove items, "Mylar" rolls back.

DU PONT
REG. U.S. PAT. OFF.

*"Mylar" is Du Pont's registered trademark for its brand of polyester film.

Better Things for Better Living . . . *through Chemistry*

DU PONT
MYLAR
POLYESTER FILM

For more information, turn to Reader Service card, circle No. 375

Martin engineers review an electronic value engineering program. The author is standing.

Why not cut costs by

Value Engineering

- *What is value engineering?*
- *The three steps to follow in making a value analysis*
- *How to set up a value engineering program*
- *How value engineering can help you pick the best material and process*

by Robert E. Parsons, *Manager, Electronic Cost Optimization, The Martin Co.*

Simply stated, value engineering is a method of finding the least expensive way to make a product. Offhand, value engineering might seem like a fancy new name for something all of us are constantly striving to do, namely reduce costs. However, there is a difference.

The relatively new art of value engineering differs from many previous cost reduction attempts in that it is not haphazard; it is a formalized method that can help you to choose the least expensive materials and product design. Traditionally, many companies have not had formal procedures for carrying out a cost savings and reduction program and have relied on individual designers and engineers to work out cost savings steps on their own as best they could. In many cases the individual approach has worked fine, but it has inherent weaknesses in that each engineer has his own system for cost reduction and there is no way that individual engineers can coordinate and concentrate their cost reduction efforts.

Value engineering is a versatile tool and can be effective before, during or after product design. It can be performed on an individual basis. However, many companies find that value engineering works best by having a separate group of value engineers who work with design engineers or who function as a catalyst in a design task force.

Follow these three steps to make a value analysis

1. Learn what the part is and what it does.

This is probably the most important step in a value engineering program. Before you can make any cost analysis on a product you must know exactly what the part is supposed to do and what is required of it. This means that you will have to make a close study of all pertinent design parameters and discuss the part's function with everyone concerned with its design. In this way you will be able to find out which requirements are important and which requirements, though nice, are not really necessary.

2. Find out alternate ways to make it.

This step is a search to find out "what else will do the job." You should work out all possible approaches to the problem, and you should try to stimulate the creativity of the engineers and encourage suggestions for feasible alternatives. Even ideas that fall short of the objective are useful because they can often be used as stepping-stones to working solutions. Once you have drawn up a list of all possible alternatives, you can weed out those ideas which are obviously unsuitable and concentrate on those that look practical.

Let's stop for a moment and see how the points just discussed work in actual practice.

Fig 1 shows a rack assembly from a Martin missile test and checkout system containing a large number of fastening forks which were given a thorough value engineering analysis. In accordance with Step 1, we learned everything we could about how the assembly works. The chassis is designed for easy maintenance through special fasteners that disengage the chassis and rack when convenient push buttons are pressed. The handles mate with small shear forks (see inset) on the rack front which carry considerable loads.

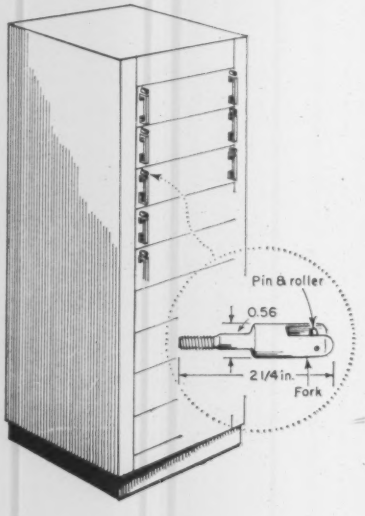
Once we learned the fork's functions the next step was to find out the best way to design and make it. After sifting many possible fork designs, materials and processing techniques, we came up with three designs that looked promising:

Design A—This, the engineering test model version, was a three-piece assembly consisting of a hogged-out steel fork, a roller and a pin.

Design B—A steel investment casting with a separate roller and pin. It features a minimum of machining but requires initial engineering, tooling and procurement costs.

Design C—This also consists of an investment casting but differs from Design B in that two parts are eliminated by using an integral pin design. Like Design B, it requires little machining but does require initial engineering, tooling and procurement costs.

Having worked out the most promising alternatives, the next step was to . . .



1 *Small shear fork used in missile test and checkout systems was narrowed down to three designs: a) machined bar with pin and roller, b) casting with pin and roller, or c) casting with integral pin.*

3. Compare costs

Once you have decided the alternatives, break down the operations of each method into step-by-step procedures. Then you can thoroughly analyze the cost of each step and compute a total cost.

At Martin we believe that value engineers should conduct the actual cost analyses. The reason is that our philosophy usually calls for before-the-fact value engineering, i.e., analysis before the design is released to engineering. At this stage no formal engineering exists and, because concepts are sometimes hazy, it is difficult to use formal cost accounting or other similar methods. However, because the value engineer is design-oriented it is possible for him to make a cost evaluation early in the game even though all the loose ends of the design are not tied down.

Prepare a standard form

A good way to keep track of cost analyses is to use a standard form such as that shown in Fig 2. Note how the form has been used to analyze the cost of the three designs described above.

The information given in the form should be a complete cost summary of all the alternatives considered. The heart of the form is the tabular main section which lists the detailed recurring and nonrecurring costs associated with each alternate. The recurring costs are unit costs that are incurred each time the part is made; the nonrecurring costs are initial costs.

Include these cost items

These common recurring costs

Value Engineering
Comparative Cost Study[a]

Study No.: _____
Page No.: _____
Date: _____
Reference Study No.: _____
Drawing No.: _____

Part Description: Fork Ass'y and Details
Machined bar with pin and roller vs Casting
with pin and roller vs Casting with integral pin

Parts Per Rack: 18

Parts Per Contract: _____

Model: _____
Requested By: _____
Prepared By: _____
Approved By: _____
Racks Per Contract: _____

Proc. and Mat'l.	Design A: Machined 4130 with Pin and Roller						Proc. and Mat'l.	Design B: Invest. Casting with Separate Pin and Roller						Proc. and Mat'l.	Design C: Invest. Casting with Integral Pin					
Recurring Cost				Non-Recurring Cost			Recurring Cost				Non-Recurring Cost			Recurring Cost				Non-Recurring Cost		
Item	Total $	Lot	Unit $	Item	Hrs	$	Item	Total $	Lot	Unit $	Item	Hrs	$	Item	Total $	Lot	Unit $	Item	Hrs	$
Mat'l.			.17	None			Mat'l.			.63	Procmnt.		50.00	Mat'l.			.55	Procmnt.		50.00
Mfg. Set-up[b]	124.00	50	2.48				Mfg. Set-up[b]	24.20	50	.48	Tool Vend.		450.00	Mfg. Set-up[b]	20.50	50	.41	Tool Vend.		480.00
Mfg. Run[b]			4.93				Mfg. Run[b]			2.64	Engrng.	128	1250.00	Mfg. Run[b]			.89	Engrng.	128	1250.00
Total			$ 7.58	Total		$0	Total			$ 3.75	Total		$1750.00	Total			$ 1.85	Total		$1780.00

Recommended Design: Design C

Break-Even Points: Design B vs Design A: 458
Design C vs Design A: 310
Design C vs Design B: 16

[a]Notes:
1. Typical lot size of 50 is assumed except as noted in [b].
2. Total savings: $_____.
3. Tools confirmed by: _____.
4. Engineering designs confirmed by: _____

[b]Cost based on standard time at 100.

should be included in the value analysis:

Material—Estimate on a "per part" basis, including scrap allowance.

Run time—This important labor cost item is calculated by determining how long it takes to make each part and multiplying by the appropriate wage rate.

Setup—Unit cost of preparing machines and equipment.

Others—Include special handling costs, planning or engineering release costs, etc.

Include also nonrecurring costs (first costs) such as:

Engineering — Basic engineering costs plus design support costs (i.e., liaison, materials, components and checking costs).

Tooling (company) — Calculate total labor cost for tool design and construction plus cost of tool materials used. Do not include facilities.

Tooling (outside vendor)—Outside vendor tool charges such as patterns, dies and molds.

Setup (outside vendor) — Cost of changes required to supply special, rather than off-the-shelf, components.

Tests—Cost of all initial and follow-up environmental and functional performance tests.

Others—Include cost of procurement and design changes.

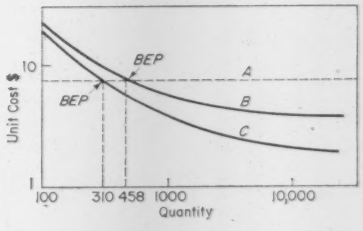
Find the break-even point

The break-even point is the number of units at which one design is more economical than another. It is the heart of a value engineering recommendation and can be simply calculated by the formula: BEP = $\Delta NR \div \Delta R$, where BEP = break-even point; ΔNR = nonrecurring cost difference between two designs; and ΔR = recurring cost difference between two designs.

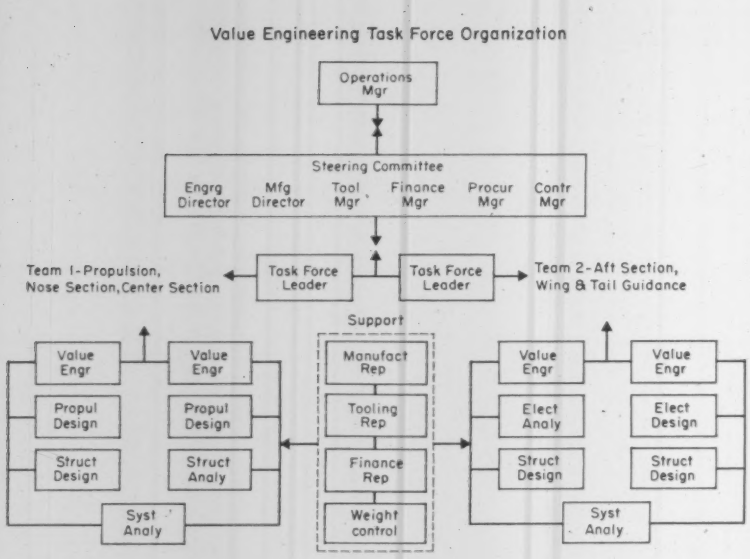
Let's examine designs A and C of the fork study to learn how the formula works. From Fig 2 we learn that the nonrecurring costs are: NR_C = \$1780, NR_A = \$0; and that the recurring costs are R_C = \$1.85, R_A = \$7.58. Thus, BEP = (\$1780 — \$0) ÷ (\$7.58 — \$1.85), or 310 units.

2 *Standard cost analysis form.*

3 *Graphical presentation of data will help you visualize cost of alternatives and break-even points. The three designs: A, machined bar with pin and roller; B, investment casting with pin and roller; C, investment casting with integral cast pin.*



For added clarification you can also make a graphical comparison of the total cost (recurring plus nonrecurring) of each design with different production quantities. Fig 3, which shows the crossover cost points for the shear forks previously discussed, vividly demonstrates which design is least expensive.



4 Typical task force group set up for value analysis of missile program.

You can organize a value engineering program to . . .

. . . meet pre-set costs

The first step in meeting pre-set or target costs is to have your engineering department prepare a detailed work statement on the part and its design. This statement should then be circulated among the project managers—procurement, tooling and manuturing—so that they can break down their own workload into subtargets and prepare estimates of how much it will cost to fabricate the product. When all estimates have been completed they should be sent to the finance manager for checking and to find out if they are commensurate with the original statement of work.

Value engineering can be a valuable tool in estimating the above costs. Knowing your target costs is only half the battle and it is important that you set up a working procedure such as the following to make sure that the cost can be maintained:

1. Break down the target cost into smaller unit costs for each phase of the design.

2. In the event that target costs cannot be met, be prepared to analyze the cost of less expensive alternative designs.

Great benefits can be obtained by having the value engineer and designer work as a team. A value engineer can be of great help in evaluating the cost of the first design approach and, if the cost is above target, in helping the designer work out a new approach.

This "cut-and-try" approach should be repeated until the estimated cost is within budget or until it is obvious that the target cost will be exceeded. In this case the finance manager should be informed of the target overrun so that he can determine whether or not this is simply an isolated overrun that will be balanced by other target underruns and thus will not affect the overall program. If the target is one of many overruns and it looks as though the overall program is in trouble then the finance and operations manager may have to take corrective action.

. . . reduce cost of products already in production

In many cases we have found that cost reduction can best be accomplished by using the services of a separate value engineering task force. Such a task force is especially valuable in reducing the cost of a product that is already in production.

Fig. 4 diagrams a typical task force group that we set up on a missile program. This task force is split into three separate groups—a steering committee, two value engineering teams and a support section—that are supposed to:

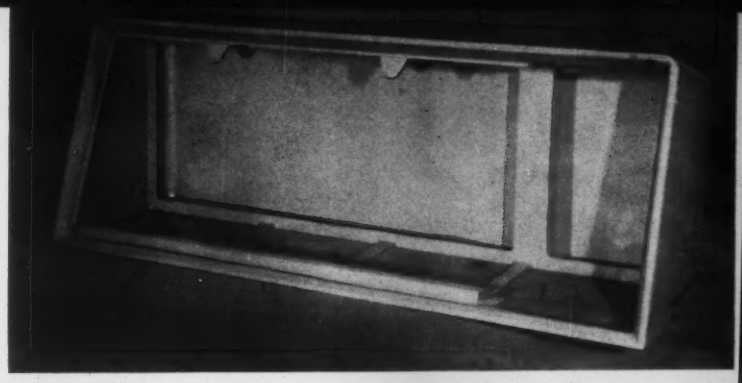
1. Determine high cost areas. These areas are established by the steering committee and the support section from existing accounting, procurement and manufacturing records.

2. Take a second look at function vs cost. To do this Monday morning quarterbacking properly, the designers assigned to the group should be better than average. They should not have been associated with the original design.

3. Create lower cost alternatives. In this case the value engineering team, rather than the project designers, create the lower cost approaches. Usually, the value engineering study is initiated by the team leader who learns the high cost areas from the support section or steering committee (see Fig 4) and assigns a value engineering team, consisting of value engineers and appropriate designers and engineers, to the problem. This team is helped by members of the support section—manufacturing, tooling and finance—who supply specialized cost estimates and financial advice.

After the best low cost alternative has been decided on, the proposal is reviewed and approved by the value engineering team leader. He then sends the proposal to the steering committee for review; if it is accepted, the budget is approved and the original design group is requested to make the appropriate changes. The changes are not made by the value engineering team, as it is strictly an advisory group.

And value engineering can help you to . . .



Display console

. . . select the right material

One of the most important benefits of a value engineering study is that it enables you to find out which material will be the least expensive for a particular product or component. The display console shown in the accompanying photo is a good case in point. Early in the program the designers of this console were undecided if it should be made from a conventional welded steel frame covered with a reinforced plastics shell or if it should be made as a large thin-walled aluminum casting. Subsequently, a value engineering study showed that the aluminum casting would only cost 50% as much as the plastics laminate design. Naturally, the aluminum casting was selected and, in the quantities needed, produced a savings of about $14,000.

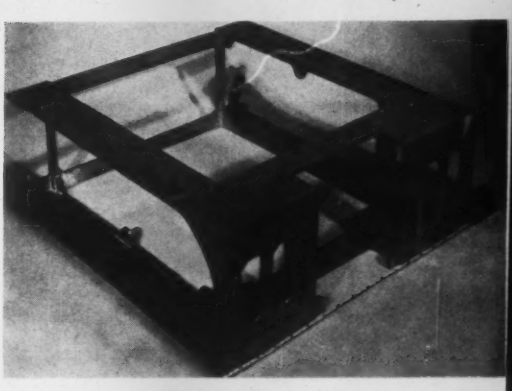
. . . select the right form

Value engineering can also help point out the right process, or form of material to use, e.g., sheet, extrusion, forging, casting or other form. Martin recently received an order for increased quantities of electronic equipment containing a chassis which, in accordance with the original production order, consisted of an integral sand casting. In light of the larger order it was decided to evaluate the costs if the chassis were made as an integral semi-permanent mold casting, or as a built-up assembly consisting of two die castings and two permanent mold castings. Value analysis showed that the semipermanent mold chassis (pictured) was the least expensive in the quantities needed. Compared to the most nearly competitive design, it produced a savings of $97,000 in processing and machining costs.

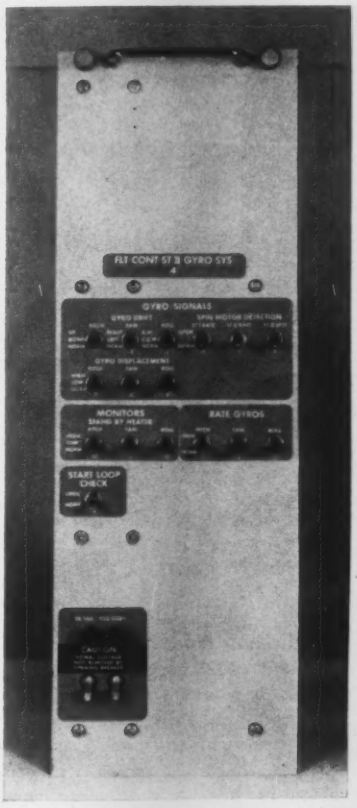
. . . decide whether to make it or buy it

Value engineering plays an important role in many minor "make-or-buy" decisions. We had a good example of this recently with an electronic checkout device which required front panel markings. An evaluation was made to find the least expensive method of marking the panel fronts so that expected markings changes could be made easily in the field without removing the panels. This evaluation narrowed down to two marking techniques: 1) in-shop silk screening and engraving on little metal plates which are subsequently bonded to the panel; and 2) use of vendor-supplied, permanently marked polyvinyl chloride overlay pads containing a pressure-sensitive adhesive backing. A comprehensive analysis of both techniques showed that the vinyl overlays could be used at a savings of $3500.

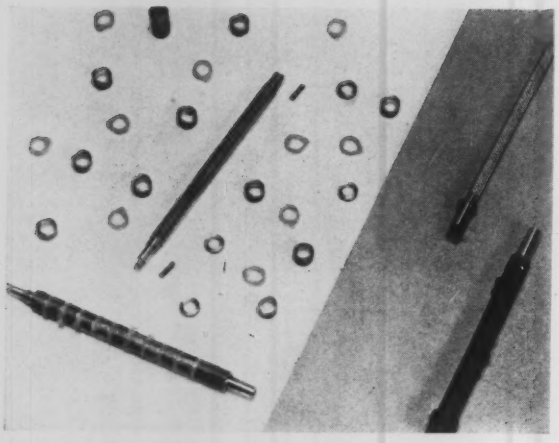
Value engineering is also commonly used to make analyses of various machining methods. Most of these analyses deal with the relative cost of using production vs job shop setups. Sometimes we make analyses to find if it would be economical to use a special piece of equipment owned by an outside vendor. For example, we recently figured that $3800 could be saved on the production run by having an outside shop burn out a complex configuration from heavy stainless steel plates. We did not have the special equipment ourselves and the alternate machining methods that we would have had to use were too time-consuming to consider.



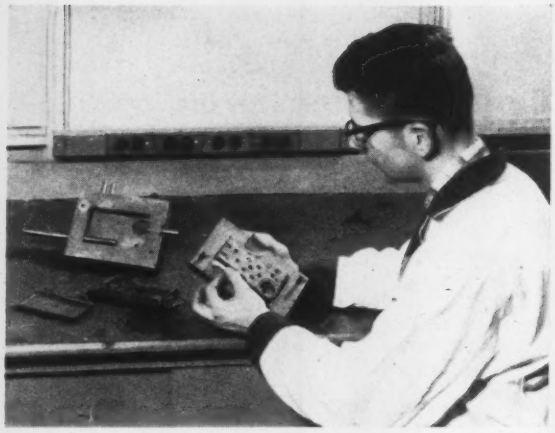
Electronic chassis



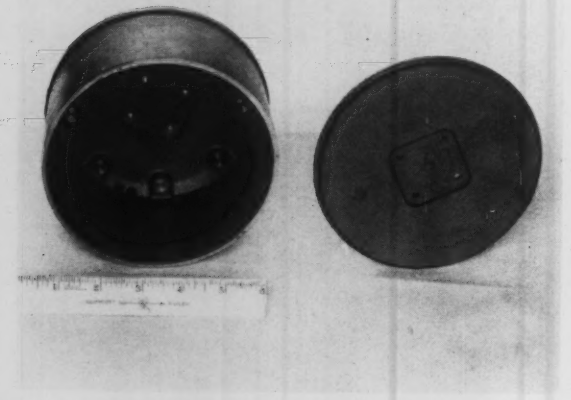
Panel markings



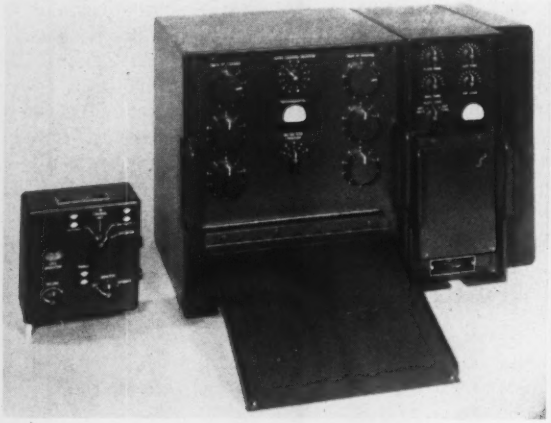
Miniature precision camshaft *cast from epoxy (right) replaced metal-nylon assembly (left) at saving of $3200, or about 70%. Split, cold rubber molds were used. When camshafts were removed from the mold after curing, they were ready for installation.*



Pocket-size transceiver case *is cast from epoxy in an epoxy mold, saving $1300 over machining from aluminum. Aluminum castings would cost considerably more. Case was produced in half the time required by other methods. Here, metal inserts are fitted into mold.*



Housing for magnetic sensing device *is molded from an aluminum-filled epoxy. Metal inserts are held securely in the base and close tolerances permit assembly of internal panels. The mold is made from the same epoxy.*



Radio transceiver case *is made by alternating layers of brush-applied epoxy with glass cloth strips. Epoxy knobs, switches and meter blocks were added. Lay-up method was the most economical considered by military.*

Epoxies Save Time, Money

in Electronics Systems

■ Switching from metals to epoxies has saved Motorola Inc.'s Military Electronics Div. up to 50% of the original fabricating cost for many pieces of equipment.

Even more important is the saving in time. A Motorola spokesman says: "Epoxy is ideal for our type of work, since most of the time the military does not require large quantities. And it is generally in a hurry."

Motorola now makes models, dies, mock-ups, cabinets and components in its own shop. This gives them better control and flexibility to accommodate last minute or future changes.

Engineers in Motorola's new plastics department were assisted by Ren Plastics, Inc., Lansing, Mich. in selecting and processing the epoxies supplied by Ren for each of the four uses above.

A progress report:

Ultra High Temperature Textiles

Again the needs of the military are straining the capability of an old materials technology—the technology of textile fibers. How far have we come in closing the gap between the present high temperature limits of organic textiles, about 500 F, and the required 1800-2000 F?

■ Strong, lightweight, flexible fabrics that have controllable, low porosity, yet can survive temperatures on the order of 1500 to 2000 F: these are among the requirements for drag chutes and other deceleration devices for satellite reentry.

Admittedly such applications are highly specialized, even esoteric. But it appears that such materials could be put to practical use in other much broader industrial applications. Even now there is need for high temperature tire cord for aircraft and trucks . . . higher temperature reinforcing fabrics for plastics, ceramics and metals . . . high temperature fabrics for filtering flue gases from pressurized boilers to turbines . . . high temperature filtering media for smokestacks and for chemical processing gases and liquids.

The field of high temperature textiles has been little explored. Textiles that meet these requirements have not been developed. We face problems in both materials and fabrication. But progress is being made.

Air Force sponsored research at ADL (Arthur D. Little, Inc.) and FRL (Fabrics Research Laboratories, Inc.), among others, has resulted in a thorough appraisal of the present status of high temperature textiles. This article is a summary of what we know at present, including a look at the most promising materials we have.

by Myron J. Coplan,
Assistant Director,
Fabrics Research Laboratories, Inc.
and Dennis E. Johnson,
Arthur D. Little, Inc.

Fibrous materials: metals have the edge

Although it is too early to say with certainty which type of material will best meet requirements, at present metals seem to hold the edge. Certain of the ceramic fibers are also promising, e.g., quartz and high silica glass fibers. These appear even more promising by comparison when the problems of weaving multifilament metal yarns are considered.

Organic fibers (with the possible exception of a recently developed "refractory" organic fiber) appear to be out of the running when it comes to retention of strength at temperature; the maximum use temperature of the best organic fibers is around 500-600 F.

Superalloys: 1400 to 1800 F

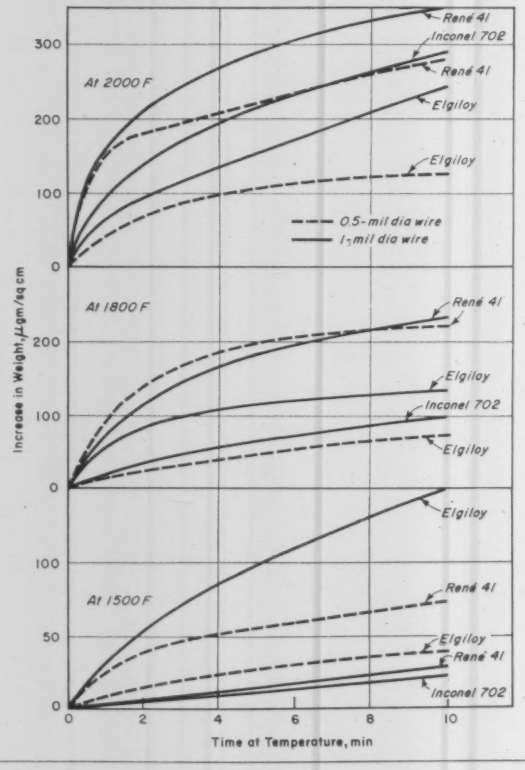
In evaluating metal filaments we decided to concentrate on the superalloys, because they have the highest strength-to-weight ratio as well as the highest oxidation resistance (without coatings) at temperatures of 1400 to 1800 F. By comparison, strengths of stainless steels fall off rapidly in the 1000 to 1400 F temperature range.

One of the most critical problems has been to obtain filaments in fine enough diameters. Availability of 1-mil wire in various alloys is reasonably good. But diameters smaller than this cause problems. Smallest diameter obtainable was 0.5 mil. Quantities of such wire were obtained in the cobalt-chromium alloy, Elgiloy, and in the nickel-chromium alloy, René 41. Larger diameter wire, 1 and 2-mil and greater, was also obtained in Elgiloy and René 41, as well as the nickel-chromium alloy Inconel 702.

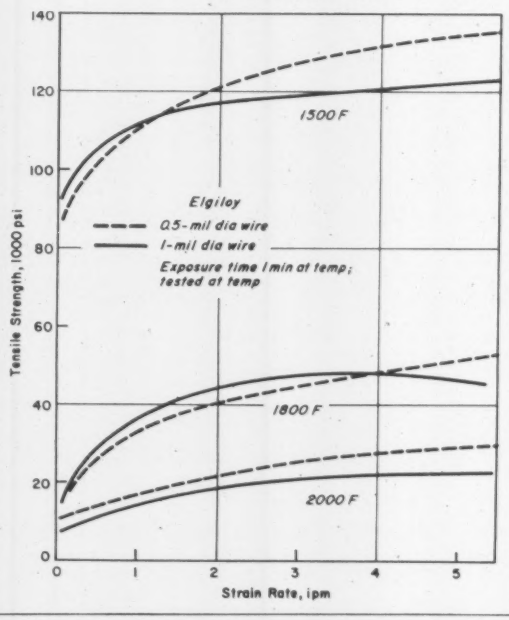
Oxidation rates for these alloys in two wire sizes—1 mil and 0.5 mil—are summarized in Fig 1. Oxidation studies were also made on wire ranging up to 5 mils in dia. We found that as wire diameter decreases, 1) oxidation rate (penetration) decreases, and 2) percent reduction of area increases.

At temperatures of 1500 to 2000 F, apparent tensile strength was found to increase with strain rate up to strain rates of about 5 ipm. Fig 2 shows effects of strain rate on tensile strengths of 0.5 and 1-mil Elgiloy wire at 1500, 1800 and 2000 F. Fig 3 shows the same for 0.5-mil dia René 41.

In all wire sizes of both types, tensile properties fall off very rapidly above 1500 F. Fig 4 shows effects of temperature on tensile strength (after 1-min exposure) of 0.5 and 1-mil dia wire of both René 41 and Elgiloy. Strength was measured at temperature, and the 2-ipm strain rate was selected be-



1—*Oxidation rates vs time for wires of refractory metals.*
(ADL 3rd Quarterly Progress Rpt.)



2—*Tensile strength vs strain rate for Elgiloy wire.*
(ADL 4th Quarterly Progress Rpt.)

TABLE 1—APPROXIMATE MODULUS VS TEMPERATURE AND STRAIN RATE*

Alloy	Strain Rate, ipm	Modulus at Temp, 10^6 psi			
		Room	1500 F	1800 F	2000 F
Elgiloy	0.2.....	23.0	4.3	1.8	0.49
	0.5.....	28.8	4.5	2.4	0.85
	1.0.....	26.8	5.0	2.8	0.99
	2.0.....	27.4	4.7	3.0	1.7
René 41	0.2.....	24.2	5.5	1.4	1.4
	0.5.....	25.2	6.1	2.3	1.6
	1.0.....	25.3	5.9	3.5	1.8
	2.0.....	23.4	6.2	—	2.4

*All wire 0.5 mil dia. Test instrument used did not permit accurate measure of gage length; thus accurate measurement of modulus was impossible. Also, clamp slippage error is present as indicated by measured room temperature modulus for René 41 of 24.2×10^6 psi vs 29×10^6 psi reported in the manufacturer's literature.

cause it provided maximum reproducibility.

Time of exposure has little effect on tensile properties at 1500 F, and only a slight effect at 1800 and 2000 F, as shown in Fig 5.

Modulus calculations are only approximate. The nature of the platinum furnace used for high temperature testing was such that jaws had to be located outside the furnace, and there was no exact method of measuring elongation of specimens. But even though strain values could be in error by as much as 50 to 100% we can draw some definite conclusions about modulus.

Table 1 shows calculated moduli for wire of both alloys at various temperatures. It is obvious that 1) modulus decreases by several orders of magnitude between 1500 F and 2000 F, and 2) modulus appears to increase with increasing strain rate in the 1800-2000 F range.

These observations strongly suggest that these two alloys behave in a plastic rather than elastic manner in the 1800-2000 F temperature range. Thus, creep may be a better criterion for judging metal wire in this high temperature range. A program of short-term creep studies is now under way at ADL.

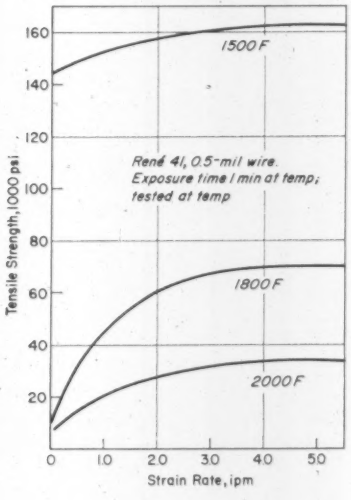
In summary, it appears that certain of the nickel and cobalt-base superalloys retain sufficient strength, elongation and toughness to be usable at temperatures up to 1800 F. But shortly above this temperature, between 1800 and 2000 F, the proportional limit drops off rapidly so that nonrecoverable plastic flow or creep starts at a low stress level.

Refractory metals need coatings

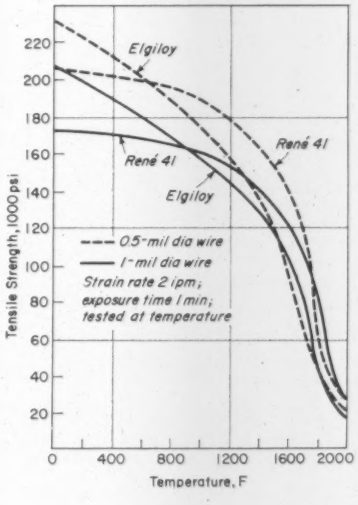
At temperatures above 1800 F, refractory metal fibers offer promising strength-to-weight ratios. But their high reactivity causes catastrophic oxidation unless they are protected.

Many methods of applying heat resistant coatings to metals are available, but little information has been developed about their suitability for coating fine wire—particularly wires made of reactive metals such as molybdenum

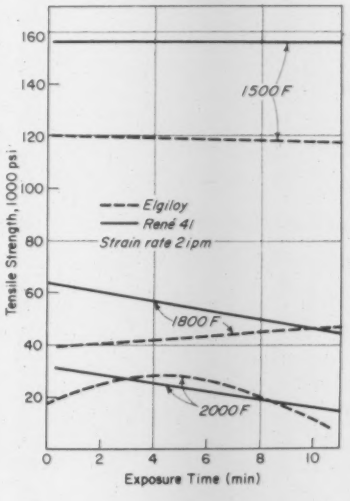
3—*Tensile strength vs strain rate for René 41 wire.*
(ADL 4th Quarterly Progress Rpt.)



4—*Tensile strength vs temperature for Elgiloy and René 41 wires.*
(ADL 4th Quarterly Progress Rpt.)



5—*Effects of time at temperature on Elgiloy and René 41 wires.*
(ADL 4th Quarterly Progress Rpt.)



and tungsten. Requirements for such coatings are stringent: Since the filament itself must be on the order of 0.5-1 mil in dia for sufficient flexibility, coatings must be on the order of 0.1 mil or less. Further, they must be essentially pore-free, oxidation resistant, adherent, resistant to erosion by high velocity gases, and sufficiently ductile to withstand repeated bending without cracking.

Possible coating methods include cladding, electroplating, electroless plating, and vapor plating. In the initial evaluation stages, cladding was discarded as posing too many problems in maintaining a consistent coating thickness during drawing.

Studies of electroplating and electroless plating have been quite extensive, though relatively unsuccessful. Coating systems investigated on 1-mil molybdenum wire include electroless nickel-chromium-rhodium, and nickel strikes combined with electroless nickel-chromium and electroless nickel-chromium-rhodium. Initial results in some cases were somewhat promising, but the most recent testing in air at 2000 F resulted in specimens with the best coatings burning up completely after exposures ranging from as little as 15 sec to as long as 60 sec.

Vapor plating techniques appear promising and are now being studied. Work is presently being carried out on vapor plating 0.05-0.1 mil chromium on 1-mil molybdenum wire. Current plans also include vapor plating a composite chromium-nickel coating.

Ceramic fibers may work

The potential advantage of ceramic or glassy fibers over metallic filaments are their resistance to heat and oxidation and their low density. But data on strength of such fibers at elevated temperatures are incomplete.

The major problem common to those ceramic fibers currently available which might be usable in the 1500-2000 F temperature range is susceptibility to abrasion which drastically lowers strength. Further, strength values are highly variable and inconsistent. Variability is primarily due to defects at the surface of the fiber incurred during fiber production or subsequent handling.

Judging by the patent literature a great deal of work is being done on metal coating of ceramic fibers to protect them from abrasion. But as yet no commercial announcement of practical coating techniques has been made.

Available ceramic fibers—Currently available ceramic fibers are limited to 1) conventional fibrous E glass, 2) quartz or fused silica, 3) high silica fibers (leached borosilicate glass, e.g., Refrasil or Sil-Temp), 4) aluminum silicate, 5) potassium titanate, 6) asbestos, and 7) graphite. Insufficient heat resistance immediately eliminates conventional fibrous glass and asbestos from consideration. Potassium titanate is producible only in lengths up to ½ in., limiting its practical possibility even for producing staple yarns.

Looking at the other fibers mentioned:

- A group of six fused silica filaments made by General Electric Co. show tensile strengths ranging from 55,000 to 180,000 psi, the average being 119,000 psi. Silica yarn made up of 200 continuous filaments has a room temperature strength of 81,000 psi, diminishing to 12,000 psi at 1600 F.

- For aluminum silicate glass fibers 0.5 to 1 mil in dia *Silverman* claims extremely high tensile strengths. His values range from 625,000 psi at room temperature to 304,000 psi at 1400 F. The room temperature value is much higher than the average value reported by Carborundum Co. for its Fiberfrax aluminum silicate fiber (i.e., 150,000 psi). Carborundum has no data on the higher temperature strength of individual filaments of its fiber.

- Although manufacturers have made some initial measurements of the high temperature strengths of leached silica fibers, they consider the results unreliable and have not released them.

- Graphite textiles have been produced for some time by National Carbon Co., but fiber strengths are not consistent. Values as high as 50,000 psi at room temperature have been reported Although the strength-to-weight ratio of graphite fabrics is highly promising (particularly so since graphite increases in strength with increasing temperature), it is necessary to protect these fibers from oxidation above about 750 F.

Developmental ceramic fibers—Many ceramic fibers are reported under development, but little realistic evaluation of them can be made as yet.

Some of the more interesting are summarized here:

- Refractory glasses of various compositions have been under development by Carborundum Co. under Air Force contract. To date, the most promising has been one with a calculated oxide batch composition of 82% SiO_2, 8% Al_2O_3, and 10% BaO. Highest values obtained from such filaments were 138,000 psi at room temperature and 132,000 psi at 1500 F. The filaments were drawn and coated at the bushing with a silicone composition.

- Several high-hot-strength silica-based fibers are under development by Owens Corning Fiberglas Co. under contract with the Navy's Bureau of Aeronautics. Filaments from such glasses fired at 1800 F for ½ hr were found to be significantly stronger than quartz filaments under the same conditions.

- A polycrystalline refractory glass fiber under development by General Electric is said to have almost as high a tensile strength at 1500 F as conventional fiber glass at room temperature. So far it is made by an unconventional process not adaptable to forming continuous fibers.

- Fibers made of a variety of types of metal oxide have been reported by Horizons, Inc. Minerals and Chemicals Corp. is reported to have taken a license for the process and to be designing and constructing a pilot plant to produce zirconium dioxide fibers. Such fibers, said to be producible in lengths ranging from short to medium

staple, have a melting point of about 4700 F. Again the problem of spinning such fibers into usable yarns would raise formidable problems.

Organic fibers a bare chance

Although virtually no organic fiber has sufficient heat resistance to be considered, certain types of organic fibers may well be useful if employed in a different approach to heat resistance, i.e., the metamorphic approach which is discussed later.

We should mention here a relatively new organic textile material called Pluton, developed by Minnesota Mining & Mfg. Co. It is said to be nonmelting at temperatures up to 18,000 F, although no strength data at elevated temperatures have been reported. Composition of the material is undisclosed. FRL is currently evaluating the material. Although room temperature strength appears low, the fiber might be particularly useful as a core yarn in combination with metal filaments.

Problem: how to engineer a fabric

Virtually no information is available on weaving fine mesh metallic textiles from multifilament yarn. In order to obtain sufficient flexibility in a textile made of high modulus materials such as metals (moduli greater than 10^7 psi), filaments must be on the order of 0.5 mil in dia, as shown in Table 2. Weaving of such fine wire is scarcely done in this country (an exception being Unique Wire Weaving Co., Inc.). In fact virtually all fine wire cloth in this country is imported from West Germany—West Berlin in particular, as it happens.

Engineering of yarns compared

The magnitude of the problem can be visualized by comparing engineering requirements of a metal yarn with those of an organic yarn. For a typical parachute yarn of required strength, flexibility and recoverability from flexing, an organic yarn may require 75 filaments. To meet the same strength and flexibility requirements a metallic yarn would require 7500 filaments. Beyond the formidable problem of bunching and spinning so many metal filaments is the high cost of so much fine wire. For example, the wire drawing technique currently used to produce fine continuous wire puts the cost of 0.5-mil dia filaments of René 41 at about $2000 per lb.

Compounding the yarn problem is the necessity of weaving fabrics with porosities considered extremely low even for organic fabrics, e.g., 1% porosity. We feel that such low levels of porosity are practically unobtainable in weaving metal filament yarns alone.

Because of difficulty in locating metal cloth sample weavers capable of spinning such fine filaments into yarns, and weaving such yarns into textiles, most of the work to date has been done at FRL. Although we have successfully twisted some low twist 7/1 yarns of 0.5-mil dia Chromel alloy wire, we have been unsuccessful as yet in obtaining any woven multifilament yarn cloths.

TABLE 2—FILAMENT DIAMETER REQUIRED TO GIVE FLEXIBILITY EQUIVALENT TO NYLON AND FIBERGLASS

Material ↓	Mod of Elast, 10^6 psi	Dia for Same Flex, μ	
		As 19 μ Nylon	As 15 μ Glass Fibers[b]
ORGANIC			
Nylon	0.4	19.0	31.7
Silk	2.1	12.8	21.0
Viscose Rayon	1.6	13.7	22.4
CERAMIC OR REFRACTORY			
Carbon	0.7	16.8	27.5
Aluminum Silicate[a]	6.8	9.5	15.7
Glass Fibers[b]	8.0	9.1	15.0
Fused Silica	10.0	8.6	14.2
Aluminum Oxide	34.0	6.4	10.4
METALLIC			
Gold	12.0	8.2	13.5
Columbium	22.7	7.1	11.2
Platinum	25.0	6.9	11.2
Iron, Nickel, Copper	30.0	6.6	10.8
Tungsten, Molybdenum	50.0	5.8	9.5
Iridium	75.0	4.8	8.6

[a]Carborundum Co.'s Fiberfrax. [b]"E" type.

Composite approach promising

One promising approach to developing the required yarns is to twist metal filaments over a bulky nonmetallic core yarn. The core yarn reduces the number of filaments required, and contributes flexibility and bulk while the metal filaments provide the strength.

At elevated temperatures the core yarns would be required only to maintain their shape. A yarn which shrinks on exposure to heat may be particularly useful since the shrinkage may serve to compact the fabric structure, resulting in reduced porosity during the high heat stage of reentry (when lower porosity is desired by aerodynamic considerations). One system of interest uses a glass yarn as a core and subjects the finished composite to leaching such as that used to produce high silica glass fibers (e.g., Refrasil or Sil-Temp).

In short, the technology of fabricating the high modulus materials which may provide sufficient heat resistance is in its early stages. Much work must be done before low and predictable porosity levels can be achieved in such fabrics. At present, in addition to our work, Goodyear Aircraft Co. is currently under contract with the Air Force to develop a loom for multifilament fine wire weaving. (The article on p 15 of this issue reports some progress in weaving fine mesh monofilament yarn cloths from refractory metal fibers.) *Turn page for the "metamorphic approach"*

The metamorphic approach:

An entirely different approach to solving the high temperature textile problem is still in the theoretical stages. But if workable, it would solve both the heat resistance and the fabrication problems. Developed at FRL, it is called the metamorphic approach. It somewhat parallels the ablation principle.

The success of the ablation principle in solving the high speed reentry problem depends on the conversion kinetics of the material during reentry. Thus, the thermal and thermochemical sensitivity of the material is turned from a disadvantage to an advantage. In short, thermal degeneration is put to work.

The "metamorphic principle" as applied here consists of producing a textile of a "raw material" such as some type of organic fiber which has the required flexibility (for parachute packing) and porosity (for initial drag during the "thin air" stages of reentry). As the environment becomes severe in terms of heat, oxidation and radiation, these elements of the environment react with the raw material, converting it to another species of matter. This latter material would be characterized by greatly improved heat resistance and reasonable retention of strength, but at a sacrifice in flexibility (which would no longer be required for packing). If such a conversion could be accomplished without catastrophic destruction, the metamorphic system might be feasible.

Metamorphic Approach at Work

The metamorphic approach has already been put to use in solving the reentry deceleration problem. The inflatable Ballute, developed by Goodyear Aircraft Corp. for the Air Force, uses a metamorphic coating to protect the structural material during ram-air heating. The Ballute consists of superalloy wire cloth coated with a silicone rubber and a glass enamel frit. As reentry heat builds up to about 800 F the silicone rubber decomposes, forming a silica ash; as heat increases to the peak 1500 F temperature the glass melts, forming a viscous melt which supports the ash. Subsequent cooling after deceleration solidifies the glass, resulting in a glassy coating of high silica content on the high temperature wire mesh. The resulting composite structure is reported to have sufficient flexibility to withstand aerodynamic loading prior to ejection of the recovery chute.

How it might work

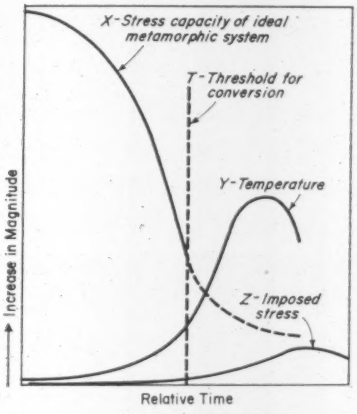
Although as yet we have insufficient information to state categorically the chances of such a system working, work in related types of metamorphosis (e.g., graphitization of rayon to form graphite textiles) makes further investigation warranted.

The mechanism utilized by the metamorphic approach can be called "scaffolding", defined as a method in which one composition of matter (stage B material) is made to assume a desired shape as the result of having been dispersed within or upon some antecedent composition of matter (stage A material). Here are several ways by which this principle might work:

Molecular scaffolding—The latent B material is dispersed intimately within the A material. Indeed, the latent B material may be an integral part of the molecular system comprising the A material.

This method has been utilized commercially in the production of several materials. For example, Fortisan cellulosic fiber is produced by acetylating native cellulose, dissolving the product in appropriate solvent, and spinning and stretching the filaments. This state would represent stage A. Subsequently, acetyl groups are re-

a possible use for organic filaments



6—*Qualitative conditions during conversion period of a metamorphic textile system.* (Coplan)

moved to yield stage B, or end-product filament.

Another example is the conversion of polyacrylonitrile to so-called "black Orlon." Simply by heating the polyacrylonitrile fiber under prescribed conditions a new composition of matter emerges having the shape of the original material but with intrinsically different properties.

Intermicellar scaffolding — The B material is distributed within the A material matrix as multimolecular aggregates rather than as single molecules. Thus, the final material can now be more easily recognized as a discrete composition of matter which may be only physically intermingled with the A material, or within limits bound to it.

Wellsbach-type fibers are an example of this type of scaffolding. Here soluble salts, such as thorium and cerium nitrates, are deposited from solutions within the intermicellar regions of cellulosic fibers. The cellulose burns off leaving the thorium and cerium oxides.

This type of intermicellar scaffolding involves after-treatment of a fully formed fiber. A scaffold structure might also be formed directly during the fiber spinning process by incorporating reagents in a fashion similar to pigmenting in so-called "dope-dyed" fibers.

Surface scaffolding—Some desirably resistant material is physically deposited on the fiber surface. Probably a combination of surface plus molecular or intermicellar scaffolding could be applicable to the metamorphic system.

Inter-fiber or inter-yarn scaffolding—The class B material is distributed among the class A materials in the form either of blended fiber bundles or of yarns. Upon destruction of the A material, the B material remains in the elongated structure determined by the initial configuration of the A materials.

An example of inter-fiber scaffolding is blended spun yarns of alginate fibers with wool. In this case the alginate is eventually dissolved out, leaving the wool in a special fabric configuration. The A material in this case is the blended yarn; the B material is the residual wool after removal of the alginate.

Conversion condition critical

The critical problem with any of the techniques is the load-bearing capability of the material during conversion. Fig 6 shows qualitatively the three parameters of temperature, imposed stress on the fabric, and stress capacity in the ideal metamorphic system. The vertical dotted line "T" is the threshold for the conversion process.

As can be seen, the conversion must be achieved rapidly and uniformly, since the imposed stress is reaching significant levels and about to reach its maximum as peak temperatures occur. Catastrophic destruction would result if Curve X intersected Curve Z at any point.

Actual conversion may occur in several ways:

1. Simultaneous crosslinking and chain scission processes leading principally to a polymeric carbon type of structure, or semigraphite.

2. Simultaneous degradation of the original carbonaceous chain structure to noncontinuous fragments, while a new system of inorganic bonds is set up.

3. Formation of a mixed network system of carbonaceous and inorganic bonds.

Prospects for metamorphic way

In the face of 1) incomplete knowledge of realizable polymers, or useful reactions for existing polymers, and 2) current lack of ability to predict thermal stability reliably over the time-scale of interest, we must express doubts as to the feasibility of a metamorphic textile drag chute system.

On the other hand, there is an almost limitless range of materials potentially suitable to the purpose which have not been assessed. Moreover, some qualitative experimental evidence has been acquired which suggests that a mixed residue of carbonaceous and inorganic materials might exhibit reasonable possibilities of stress-bearing capacity. It is not inconceivable to consider a network structure of carbon-oxygen-metal bonds with considerable stability and strength arising from pyrolyzing a properly treated organic fiber.

References

Coplan, M. J., Powers, Jr., D. H., Barish, L., and Valko, E. I., "A Possible Application of Organic Fibers in High Temperature Environment," WADD Tech. Rpt. 60-9, June '60.

Lamberston, W. A., Aiken, D. B., and Girard, E. H., "Continuous Filament Ceramic Fibers," WADD Tech. Rpt. 60-244, June '60.

Little, Arthur D., Inc.:
"Candidate Materials for High Temperature Fabrics," WADC Tech. Rpt. 59-155, Sept '59.
"Investigation of Properties of Fine Filaments and Fabrics of Superalloys and Refractory Metals for Parachute Applications," 1st, 2nd, 3rd and 4th Quarterly Progress Rpts., Materials Central, Wright Air Development Div., Contract AF 33(616)-7294; Aug '60; Nov '60; Mar '61; June '61.

Powers, Jr., D. H., Freeston, W. D., and Coplan, M. J., "Flexible Low Permeability Metal and Ceramic Cloths," Case Number C60893, Bi-Monthly Progress Rpt. No. 5, Mar '61, Materials Central, Wright Air Development Div., Contract No. AF 33 (616)-7222.

Silverman, A., "Development of High Modulus Fibers from Heat-Resistant Materials," WADC Tech. Rpt. 58-285, June '58.

Consider these eight factors in

Specifying Tubing

■ Almost all small metal tubing used to convey or contain liquids or gases is cold formed. Cold forming also is used frequently to produce mechanical tubular parts.

In some cases the operation is a severe one. Two examples: shaping and bending tubing for Bourdon gage elements, and convoluting it into flexible metal hose and bellows. Shaping, bending and convoluting can affect most of the tube length; beading, flaring and flanging, on the other hand, affect only short sections.

Specifying the correct tubing material and fabricating procedures is very important.

Everything is empirical—A selection table listing the formability of tube materials in various sizes and conditions would be ideal if it existed. However, there are many obstacles to producing the table. For one thing, formability varies with operating conditions. For another, at least seven metallurgical factors affect ability to be cold formed: composition, slight composition variations, surface condition, temper, ductility, work hardening rate and sensitivity to age hardening.

Two types of tests—There are two broad categories of tests that can be used: tests for mechanical properties, and actual manipulation tests that duplicate expected manufacturing operations.

Manipulation tests are more meaningful—and more expensive—than mechanical properties tests, but they are no guarantee of the cold formability of tubing unless they duplicate the cold forming operation. Such a test can fail, for example, because it measures longitudinal formability whereas the forming done on the tubing is transverse. Moreover, the degree of work hardening caused by testing may not be duplicated in the actual cold forming operation.

Here are eight tests, four mechanical and four manipulative, that will tell you what you need to know in order to specify tubing that will not crack or split during cold forming.

1. Tensile strength and hardness

These are the two properties most often specified. Of the two, tensile strength is preferred. For one thing, hardness tests may collapse the tube. And on thin tubing you may actually be measuring the hardness of the testing machine anvil rather than the tubing itself. Tube curvature also introduces errors into the hardness measurement. One exception: hardness tests are preferred for shaped tubing because it is difficult to accurately measure cross-sectional area for the tensile test.

Annealed materials are usually specified for cold forming and it is important to specify maximum, rather than minimum, strength or hardness figures in order to assure a complete anneal.

Table 1 lists the mechanical properties of 29 commonly used tubing materials.

2. Yield strength

Yield strength must be exceeded if permanent deformation is to occur. A large spread between yield and tensile strength gives you a wide range in which to stretch the metal.

Ability to be deformed depends not only on the spread between yield and tensile strength, but also on factors such as ductility and rate of work hardening. For this reason, check the combination of plastic working range, work hardening rate and amount of forming needed. A material with a narrow gap between yield and tensile strength, which has a low rate of work hardening, may be more satisfactory than one that combines a wide plastic working range with a high hardening rate.

3. Elongation or ductility

Ductility, as measured by elongation, is affected by the work hardening rate during fabrication. Elongation does not take work hardening rate into consideration and is usually not too reliable when determined for extremely thin wall tubing.

Elongation (see Table 1) can serve, however, as a general guide to the ductility, and therefore formability, of a metal.

4. Work hardening

You have just read how mechanical properties are closely interrelated with work hardening

for Cold Forming

by C. C. Mathews, *Superior Tube Co.*

rate. Table 1 qualitatively evaluates this rate for 29 metals commonly used to produce tubing. These rates represent, essentially, how much a tube can be cold drawn before it work hardens to the point where annealing is required for further drawing. These figures have not previously been published for materials in tubing form.

When using Table 1, remember that most tubing must be straightened after annealing (it is difficult to pack unstraightened tubing) and that straightening tends to work harden the tubing to some extent.

For the most severe cold forming operations which require the softest possible material, investigate the possibility of using unstraightened tubing. It may be necessary to forego belt polishing or identification marking of the surface, if these are specified, since tubing must be straightened before either of these operations can be performed.

5. Flaring

Flaring is the most common cold forming operation performed on small tubing, e.g., almost all hydraulic lines are coupled by flared fittings. Flaring is also used often to test general ductility.

When connecting tubing with flared fittings, increasing the flare gives a tighter joint up to a point. However, the greater the flare the higher the stress imposed on the metal and the greater the chance

TABLE 1—ANNEALED MECHANICAL PROPERTIES OF TYPICAL TUBING MATERIALS

Alloy ↓	Work Hardening Rate[a]	Ten Str(max), 1000 psi	Yld Str, 1000 psi	Rockwell B Hardness (max)	Elong (in 2 in.), %
STEELS					
Austenitic Stainless					
Type 305	1	100	34-47	90	65-45
Type 321	3	100	38-55	92	60-42
Type 347	4	105	38-57	92	55-35
Type 316	5	—	—	—	65-45
Type 304	6	100	34-47	90	65-45
Type 304L	6	100	34-47	90	65-45
Ferritic Stainless					
Type 430	1	85	40-55	87	40-25
Type 446	2	95	45-75	92	35-20
Type 403	3	85	35-50	90	35-22
Type 410	4	85	35-50	90	35-50
Low Carbon					
AISI 1008	1	55	26-40	60	45-35
AISI 1010	2	57	28-40	63	45-35
AISI 1015	3	60	30-44	65	42-33
AISI 1020	4	65	34-46	68	42-32
AISI 1035	5	72	35-50	74	41-27
Alloy					
AISI 4130	6	85	40-65	85	37-23
AISI 8630	7	88	42-68	88	36-22
Tool					
AISI 1095	8	88	50-70	92	35-22
AISI 52100	9	98	45-70	100	34-22
NONFERROUS METALS					
Nickel					
A Nickel	1	75	15-35	70	45-33
Monel	2	85	30-45	73	45-32
Ni-Span C	3	98	30-50	80	45-30
K Monel	4	105	40-60	90	45-30
Inconel	5	100	30-50	90	50-35
Inconel X	6	140	45-80	29[b]	35-60
Reactive Metals					
Titanium A-40	1	80	35-60	95	22[c]
Zirconium	2	70	30-50	86	30-18
Zircaloy 2	3	80	40-60	90	30-15
Beryllium Copper	—	75	10-30	75	55-35

[a]Within each group, lowest numbers indicate lowest rate. [b]Rockwell C. [c]Min.

to produce cracks or other defects. Therefore compromise is needed.

Most tubing in aircraft uses flared fittings and is covered by Military Standard 33584 which specifies a 74-deg included angle in the flare (see Table 2) and calls for a large flare diameter.

Three methods are used to flare tubing:

- Spinning. Done with a machine, this is the fastest of the three methods.
- Pressing a tapered pin into the end of the tube. Slower than spinning but sometimes done when it is impractical to use a flaring machine. It is also used for short lengths and samples.
- Hammering in a plug.

When specifying tubing to be flared, remember that hydraulic quality tubing resists splitting better than standard quality, and that unstabilized grades of stainless steel flare somewhat better than stabilized grades.

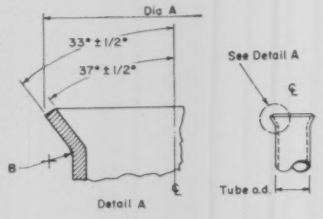


TABLE 2–STANDARD DIMENSIONS FOR STEEL OR ALUMINUM FLARED TUBING ENDS

Nominal Tube O.D., in. ↓	Dia A, in.	Rad B, ±.010 in.
1/8	0.200[a]	0.032
3/16	0.302[a]	
1/4	0.359[a]	
5/16	0.421[a]	
3/8	0.484[a]	0.046
1/2	0.656[a]	0.062
5/8	0.781[a]	
3/4	0.937[a]	0.078
1	1.187[b]	0.093
1-1/4	1.500[b]	
1-1/2	1.721[b]	0.109
1-3/4	2.106[b]	
2	2.356[b]	
2-1/2	2.856[b]	
3	3.356[b]	

[a] +.000, —0.010 in. [b] +.000, —0.015 in.

Avoid these mistakes—Mistakes made in production flaring of small tubing also apply in flare testing. The two most common are:

- Attempts to flare half-hard and hard materials. Only fully annealed or one-eighth hard tubing should be flared.
- Improper edge preparation prior to flaring. To prevent flare splitting, the tubing should be cut on a lathe, not with a hacksaw (the latter gives a rough, jagged edge), and the edge should be cut square, not feathered. Rounding the edges also promotes split-free flaring.

6. Bending

Bending is the next most common cold forming operation performed on tubing. Hydraulic lines, fuel lines and innumerable other tubular components are bent into a variety of shapes before being assembled.

Five standard methods are commonly employed: ram and press bending, roll bending, stationary die form or compression bending, rotating die or draw bending, and stretch or tension bending.

The tendency to collapse or wrinkle, particularly for light wall tubing, is a frequent bending problem. The best preventives are the use of filler materials in the tubing during bending, or bending no tighter than the recommended minimum bend radii. The minimum bend radii imposed by the mechanical methods of bending are summarized in Table 3.

Because of the variety of bending operations performed, bend test specifications are almost always tailored to the individual application.

7. Flattening and reverse flattening

Tubes are flattened by pressing between parallel plates. In reverse flattening a section of tubing is split longitudinally and the split section flattened into a strip.

TABLE 3–MINIMUM BEND RADIUS DEPENDS ON BENDING METHOD

Method	Tools	Min Radius (x o.d.)
Press	Between Centers	6
	Wing Dies	3
Stationary die	No Mandrel	2½
	Mandrel	2
Revolving die	No Mandrel	3
	Mandrel	1½
	Mandrel and Shoe	1

The ability of tubing to withstand flattening is closely related to wall thickness and chemical analysis. In flattening tests, the amount of flattening specified before the tubing shows cracks or breaks depends on the application. For welded austenitic stainless steel boiler, superheater, heat exchanger and condenser tubes, for example, no cracks or breaks can occur in the metal until the distance between the plates is less than:

$$H = (1 + e)t \div (e + t/D)$$

where H = distance between flattening plates, in.; e = deformation per unit length (constant for a given grade of steel, 0.09 for austenitic stainless steels); t = nominal wall thickness of tube, in.; and D = actual tube o.d., in.

8. Flanging

Because of its severity, flanging is performed on small tubing far less frequently than flaring, and therefore flange tests are not usually specified. One published flange test for tubing of ½ to 5-in. o.d., ASTM A249-59T, states that a section of tube not less than 4 in. in length should be capable of having a flange turned over at a right angle to the body of the tube without cracking or showing flaws. The flange, as measured from the outside of the tube, should be not less than ⅛ in. nor more than ¾ in. Within these limits the width of the flange should not be less than 15% of the tube o.d. For tubing less than ¾ in. o.d., the width of the flange should not be less than 15% of the o.d.

Progress in High Temperature Coatings

A SERIES OF FIVE ARTICLES ON TODAY'S MOST PRESSING PROBLEM IN ENGINEERING MATERIALS

M/DE Special Report No. **188**, *November, 1961,* **by Robert J. Fabian,** *Associate Editor, Materials in Design Engineering, with a special contribution on ablative coatings* **by Dr. Ray L. Hauser,** *Hauser Research & Engineering Co.*

Plasmadyne Corp.

Compact plasma arc gun *deposits refractory coatings in tight areas.*

New Coatings from the Plasma Arc

Spraying in an ionized gas stream at 15,000 F enables you to deposit as a coating just about any material you wish. Many such coatings look promising for high temperature use.

■ Coating specialists had hoped for many years that a heat source could be developed that would melt all known materials and that the combustion gases used would not react with the coating material during deposition. Plasma arc spraying has answered these requirements.

The most important single advantage of plasma arc spraying is that it can be used to deposit a large number of new coating materials for high temperature and wear and abrasion resistance applications. Actually a fairly wide range of materials can be deposited by conventional oxyacetylene flame spraying. However, plasma arc has broadened the range to encompass almost all engineering materials. At the same time, it deposits conventional coating materials with improved mechanical and physical characteristics.

Many coatings can be applied

As Table 1 shows, an impressive number of coatings can be applied by plasma arc spraying. Even though many of the coatings, such as calcium zirconate and chromium carbide, are known to have good thermal properties and high melting points, the art

is so new that few of the more exotic materials are actually being used in production. Ordinarily, high temperature coatings are developed to meet a specific application; in the case of plasma arc, however, the coatings have come first and the applications will follow.

Some of the coating materials, such as aluminum and zirconium oxides, have been available for several years through conventional flame spraying. These materials have already proved their worth. Of the new materials, however, it is too early to say which will prove useful and which will remain as curiosities.

Meanwhile the list of new coatings continues to grow. In addition to the materials listed, others now under development include tantalum, columbium, titanium nitride, chromium monoboride and a number of oxides, carbides and borides.

Process has many advantages

In addition to its ability to deposit almost any material, plasma arc spraying also:

- Enables coatings to be applied to both large and small surfaces without disassembly or difficult handling.
- Deposits coatings evenly and uniformly with close thickness control.
- Permits close control over surface finish and density.
- Does not heat the base material appreciably—substrate temperature can be maintained below 400 F.
- Can be conducted with many different gases to permit production of oxide-free coatings.
- Deposits coatings that generally have better physical and mechanical properties (especially bond and tensile strengths) than those of conventional flame sprayed coatings.
- Reduces porosity and produces high densities. Coating densities up to 98% theoretical can be easily controlled. Pure tungsten and tungsten carbide, for example, can be applied with densities of about 95% to almost any base material.

Materials melted at 15,000 F

A plasma flame is produced by passing a gas (nitrogen, hydrogen and argon are commonly used) through a confined arc where it dissociates and ionizes. The ionized gas forms a conductive path within a water-cooled nozzle so that an arc of considerable length is maintained. Coating materials in powder form are fed into the flame at a point downstream from the actual arc path. Individual adjustments in current and in gas and powder flow are made for each coating material, many of which can completely vaporize if not properly applied.

Temperature of the plasma flame depends on the type and volume of gas used, nozzle size, and amount of current. Temperatures of 10,000 to 15,000 F are generally used but higher temperatures can be attained if needed. The guns usually consume gas at the rate of 100 to 300 cfh and operate at 20 to 40 kw.

Regardless of the coating material being applied, some surface preperation is usually required because the bond is often largely mechanical. In general, the greater degree of surface roughness the better the bond. Because of their greater flexibility, thin coatings usually require less elaborate surface preparation than thick coatings.

TABLE 1—TYPICAL COATINGS APPLIED BY PLASMA ARC SPRAYING

Coating Material	Melting or Softening Temp, F	Suggested Uses
Alumina	3700	Heat and abrasion resistance, flame sprayed shapes
Calcium Zirconate	4250	Thermal barriers, abrasion resistance, molten metal resistance
Chromium Carbide	3435	Wear resistance (unfused) or as ingredient in cermets
Ceric Oxide	4712	Thermal barriers, combustion catalyst
Hafnium Oxide	5030	Thermal barriers
Magnesium Zirconate	3830	Thermal barriers, molten metal resistance, graphite coating
Molybdenum	4760	Bonding, wear resistance
Nickel	2650	Corrosion resistance (unfused, sealed), oxygen barrier, cermet mixtures
Rare Earth Oxide	4000	Thermal barriers, flame catalyst
Tungsten	6170	High temperature abrasion resistance
Titanium Oxide	3490	Abrasion resistance where low porosity is needed, and for blends with other refractories
Tungsten Carbide (crystalline)	5035	High temperature abrasion resistance
Tungsten Carbide + Cobalt	2715	Unfused—wear resistance. Fused—blended with nickel and cobalt alloys for abrasion resistance
Zirconium Oxide	4700	Thermal barriers
Zirconium Silicate	4390	Thermal barriers

*Many of coatings can also be applied by oxyacetylene flame spraying.
Source: Metallizing Engineering Co., Inc.

Acknowledgments

Metco Inc.
Norton Co.
Plasmadyne Corp.
Plasmatech Div., Valley Metallurgical Processing Co., Inc.
Thermal Dynamics Corp.

Coatings for the Refractory Metals

Several coatings are now available that will protect molybdenum, columbium, tantalum and tungsten for a few hours at about 2800 F. But no completely satisfactory coating has yet been developed to prevent destructive oxidation for long periods at high temperatures.

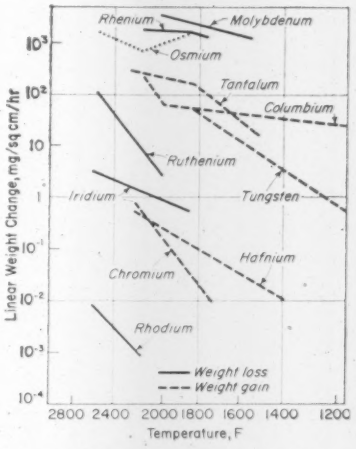
■ We can take little advantage of the high temperature strength of the refractory metals unless we find suitable ways to protect the metals from oxidizing. As Fig 1 shows, the high oxidation rates of all the refractory metals at elevated temperatures prohibit them from being used in their natural state. Many protective coatings have been tried and, despite some notable successes, much work remains to be done.

The six requirements

Development of suitable coatings for the refractory metals is difficult because the coating must:

- Prevent oxidation and contamination hardening of the base metal.
- Be stable, adherent and minimize interdiffusion so that the base metal can retain its properties.
- Restrict volatilization of the base metal.
- Repair minor defects which might otherwise allow oxidation of the base metal.
- Resist thermal shock and have a good expansion match with the base metal.
- Have sufficient ductility to withstand any strains and vibrations encountered by the base metal.

Actually, this list is just a starting point. For even if a coating does meet these criteria there is no guarantee that it will be satisfactory in production. This important point is often overlooked by coatings specialists.



1 *Oxidation rates* *of uncoated refractory metals up to 2600 F.*
(Battelle Memorial Institute)

Many current processes will undoubtedly be suitable only for small parts, whereas many of the applications for refractory metals are for large exterior parts such as leading and trailing edges for aircraft and missiles and exterior surfaces for reentry vehicles.

Another important problem that will have to be solved is how to obtain uniform, thin, adherent coatings. Also, in coating thin sheet methods will have to be developed to prevent the coating from diffusing so much that it completely destroys the properties of the base metal. Another problem facing designers is how much allowance to make in rounding off sharp sections and corners and in avoiding blind areas.

Finally, better testing methods will have to be developed. No nondestructive tests are available and even destructive tests are often a far cry from actual operating conditions. There is a wide variation in testing procedures between companies (test results often differ from one another by a factor of two) and it is often difficult, if not impossible, to compare or correlate test data. The Air Force has recognized this serious problem and has contracted with General Electric Co. to formulate standard and realistic test procedures.

Molybdenum

Molybdenum was one of the first refractory metals to be used for relatively large commercial parts. For this reason it has had a relatively long history of protective coating development. Most of the early coatings were aimed at protecting gas turbine blades from destructive oxidation at temperatures below 2000 F. Currently, however, the metal is being considered for use at much higher temperatures—as high as 3100 F. In this range the straight silicide coatings have a strong foothold; however, new modified silicate types such as the silicide-base coating containing columbium also look promising (see Table 2.)

Straight silicide coatings very reliable—In general a straight silicide coating such as the Boeing Airplane Co. coatings applied by fluidized bed and pack cementation has a life of about 2 hr at

2700 F and up to 30 min at 3000 F. Such a coating was used on the wing leading edge in Fig 2.

Similarly, the well-known W-2 coating developed by Chromalloy Corp. has lasted for more than 1.7 hr at 3000 F. The W-2 coating (modifications of which are also being used on the other refractory metals) is said to be "self-healing" above 2400 or 2500 F. Work is now underway to improve the reliability and performance of the W-2 coating so that it can be established as the basis for an Air Force specification.

Several modified silicides under development — Good performance can also be obtained with duplex silicides such as those developed by Metallic Research Laboratories, Ltd., of England. The Defense Metals Information Center (DMIC; see box on p 131) reports that these pack cementation coatings consist of a base coat of chromium or chromium-aluminum underneath a silicon, silicon-chromium, or silicon-chromium-aluminum topcoat. They have lasted as long as 3 to 5 hr in an oxidizing flame at about 2900 F.

Relatively long life is also provided by Pfaudler Co.'s PFR-6 silicide-base coating containing columbium. This coating, which has lasted for 1.4 hr at 3000 F in oxidizing flame tests, is especially noted for its ability to withstand moderate elongation without fracturing.

Considerable attention has recently been focused on a new series of heavily alloyed silicate coatings (AMFKOTES) developed by American Machine and Foundry Co. for molybdenum and the other principal refractory metals. Coatings for molybdenum are claimed to be superior to the W-2 and PFR-5 coatings. Although it is too early to make any firm conclusions about their performance, preliminary results have been impressive. For example, under an oxidizing torch the coatings are claimed to last for 125 hr at 2500 F, 6 hr at 3000 F or 1 hr at 4500 F. The coatings are usually applied 1 to 1.5 mils thick but up to 2.5 mils can be deposited if necessary.

Where to Obtain Latest Information

Because of the high interest in protective coatings for the refractory metals, the Defense Metals Information Center (DMIC) of Battelle Memorial Institute has inaugurattd a special review program. Quarterly reviews are now being published by DMIC under the title "Review of Recent Developments on Oxidation-Resistant Coatings for Refractory Metals." Two reviews are now available: DMIC Memoranda No. 102, Apr '61, and No. 120, July '61. The latest was scheduled (as of this writing) to appear last month.

TABLE 2—LIFE OF PROTECTIVE COATINGS FOR MOLYBDENUM[a]

Coating	Source	Thick, mils	Average Life, hr				
			2600 F	2800 F	2850 F[d]	2960 F[d]	3000 F
Di-Sil I[b]	Boeing Airplane Co.	1.25-1.75	—	—	1.2	0.5	—
Vought II-IX[b]	Chance Vought Aircraft, Inc.	2	—	—	3.8	1.2	—
W-2[b]	Chromalloy Corp.	2.5	—	—	1.7	0.4	—
W-2[c]	Chromalloy Corp.		>1.7	>1.7	—	—	>1.7
PFR-6[b]	Pfaudler Co.	2	—	—	2.5	1.2	—
Svstem 300[c]	General Electric Co.		>1.7	>1.7	—	—	>0.8
Al-Si[c]	National Research Corp.		0.2	0.03	—	—	<0.02

[a] From DMIC Memorandum 120, July 31, 1961.
[b] Evaluation test by Air Force using oxidizing oxyacetylene flame on 30-mil molybdenum (0.5% titanium) specimens.
[c] Evaluation test by Martin Co. conducted at 1 atm in air with zero strain.
[d] Indicated apparent temperature. All other temperatures are indicated corrected (for emissivity) temperatures. In general, apparent temperatures are 100 to 150°F less than corrected temperatures.

Columbium

Columbium will probably be used at lower temperatures than the other principal refractory metals—around 2500 F. Like the other metals it is drastically affected by oxidation at high temperatures and protection is essential. Some users tend to assume that columbium is easier to protect than molybdenum; however, columbium's sensitivity to embrittlement should not be overlooked.

The three most promising coating systems now under development are silicide coatings, alloy-modified silicides and aluminum-base coatings. As will be noted later, the zinc coatings that received much attention earlier this year have lately been found to be ineffective at high temperatures.

Silicide coatings usable to 2700 F—The silicide coatings under development for columbium are basically the same as those being used for molybdenum. Boeing is now applying straight silicide coatings to FS-82 columbium alloy by vacuum pack and fluidized bed. In the vacuum pack process parts are treated by: 1) heating in an evacuated retort containing powdered silicon at 1900 F; 2) introducing iodine vapor as a carrier; and 3) holding at temperature for 3 hr.

In the fluidized bed process the volatilized iodine carrier is introduced through a silicon bed containing the columbium parts.

Both of these treatments have effectively protected the metal up to 3 hr at 2700 F. Similarly, silicide-base coatings applied by Pfaudler to C-103, D-14 and F-48 alloys have provided protection for 4 to 18 hr at 2700 F.

Some work is also underway at Chance Vought Corp. to modify pack cementation silicide coatings to improve properties. Overcoating the silicide layer with chromium-boron or chromium-aluminum has protected columbium for about 6 hr at 2600 F.

Silicide-metallic system most reliable—The most reliable coating system yet developed for columbium is a duplex system consisting of: 1) a 1-mil bottom layer

of 50% chromium–50% titanium applied by vacuum distillation at 2350 F; and 2) a 1-mil silicide topcoat applied by vacuum distillation at 2200 F.

In cyclic oxidation tests at 2500 F this system has protected unalloyed columbium for 12 hr, D-31 alloy (columbium–10% titanium–10% molybdenum) for 24 hr, and F-48 alloy (columbium–15% tungsten – 5 % molybdenum–1% zirconium) for 20 hr. In some isolated cases it has protected columbium for over 100 hr—even up to 300 hr—at 2500 F.

The coating system is limited somewhat by the vacuum techniques required and the need for better production processes. For example, it has recently been found that coating production rate and protective life can be significantly increased by using a potassium fluoride carrier during vacuum coating.

Aluminum-base coatings are ductile—Aluminum-base coatings for columbium can be applied by pack cementation, by hot dipping, or from a slurry mixture of aluminum powders and an organic vehicle. The organic material is subsequently baked off and aluminum diffused into the base metal by a vacuum or inert atmosphere heat treatment. The coatings are more ductile than straight silicides and do not make the base metal notch sensitive—a problem that has cropped up with the silicides.

Zinc coatings have not worked out—Although early work on zinc coatings looked promising they have now been ruled out for high temperature protection. The coatings were applied by hot dipping or vacuum metallizing and formed a columbium-zinc intermetallic layer when treated at 1600 F. They can protect columbium and its alloys for 100 hr at 1800 F and for 70 hr at 2000 F, but have not proved suitable at temperatures over 2050 F. Thus the usable temperature range is too low to be practical.

The zinc coatings looked particularly promising because of their desirable self-healing characteristics. Self-healing is still of great interest and, although it is not normally found in silicide coatings, it is among the advantages claimed for the heavily-alloyed AMF silicide coatings.

Tantalum

Most of the current work on protective coatings for tantalum is aimed at protecting the metal from oxidation over a temperature range of 2200 to 3200 or 3300 F. As Table 3 shows, many different coating systems have been tried. These have met with varying success. As of this writing, the most promising systems appear to be the aluminum, beryllium and silicon-base coatings and the cermets.

Aluminum-base coatings for 2500+ F—Aluminide and beryllide coatings have protected tantalum surfaces for 10 hr at 2500 F. However, both of the coatings have failed during oxidation cycling at high temperatures because of their inherent brittleness and because of their rapid interdiffusion with the base metal. And progress with the beryllide coatings has been relatively slow because of problems associated with handling the materials.

Substantial improvements in resistance to cycling oxidation has recently been obtained by modifying the aluminide coating with tin. Coatings of 50% aluminum, 50% tin that can be applied by hot dipping, painting and spraying are now available. The paint-type coating is applied from a solution containing a nitrocellulose vehicle which is subsequently burned off. Unlike other aluminum-base coatings it is very ductile and will withstand considerable handling abuse at room temperature.

The aluminum-tin coating is particularly noted for its self-healing properties at high temperatures. This ability stems from the low melting point of the aluminum-saturated tin phase which effectively covers any cracks during deformation. After being bent and twisted, coated sheet specimens have resisted oxidation

Boeing Airplane Co.

2 Wing leading edge *of molybdenum is disilicide-coated to prevent destructive oxidation.*

for over 10 hr at about 2900 F, and have even provided protection in torch and plasma tests as high as 3300 to 3400 F.

Silicide coatings also good at high temperatures—Silicide coatings have worked out very well for protecting tantalum. Straight silicide coatings that form a protective oxide containing the pentoxide, Ta_2O_5, have proved effective for 5 to 10 hr at 2700 F.

Even greater protection has been provided by a duplex silicon-manganese pack cementation coating that forms a glassy oxide. This glassy oxide can be effective for at least 24 hr at 2700 F and appears to have self-healing properties. Compared to silicide coatings for molybdenum, the interdiffusion rate of the coating with the substrate is relatively low.

Substantial improvements in the performance of all silicide coatings can be obtained by adding materials such as vanadium, columbium and tungsten to the tantalum base. Vanadium additions in particular look especially promising because the formation of the pentoxide, V_2O_5, helps produce a protective, glassy oxide film.

Electrodeposited cermets promising—Cermet coatings have shown some ability to protect tantalum in the ultra high temperature region. Electrodeposited cermets in a chromium matrix such as Cr–ZrO_2 and Cr–ZrB_2 have

effectively protected tantalum surfaces for 6 and 20 min, respectively, in flame tests at 3700 F. Similar results were obtained using the coatings on molybdenum and tungsten.

Some approaches that failed— As Table 3 shows, other coating systems such as aluminum oxide and chromium have also been used experimentally to protect tantalum. In general, however, they have not been very successful. For example:

- Chromium coatings could not be applied in thicknesses over 0.7 mil and did not provide oxidation resistance at 2500 F. The coatings also have a serious drawback in that chromium diffusion tends to harden the base metal (up to 600 KHN for a depth of 20 mils).
- Flame sprayed aluminum oxide, with or without glass impregnation, does not protect at 2500 F because of partial oxidation of the substrate during flame spraying.
- Titanium and hafnium have been evaluated as possible additions to other coatings but are thin and nonporous when applied by pack cementation using sodium fluoride as the carrier.

Tungsten

In general, development of protective coatings for tungsten has not been as rewarding as it has been for the other refractory metals. There is not much point in using the metal below 3300 to 3500 F and at present no satisfactory protective coatings are available for higher temperatures.

Most of the present coatings for the refractory metals owe their development to empirical progress. This progress has been gratifying but it is doubtful whether the empirical approach will lick the tungsten problem. A lot of fundamental work will have to be done.

Most research is now centered around two protective coating systems: silicides and stable oxides.

Silicides usable to 3500 F— Although silicide coatings for tungsten are receiving much attention, this type of coating appears to be only a stop-gap measure; something else will be needed above 3500 F. Silicide coatings, applied by pack cementation at 1650 to 1920 F, form a glassy surface at high temperatures (silica's melting point is 3120 F). When applied under rigorously controlled manufacturing conditions they have protected tungsten for 10 hr at 3300 F in still air. Because of the surface tension of the viscous glassy layer it is believed that similar protection can be provided at fairly high air velocities.

In common with silicide coatings for other refractory metals, tungsten coatings are affected by oxidation in the intermediate temperature or "pest" range and accelerated failure has been observed from 1200 to 2300 F. Presumably failure results from porosity in the scale caused by the volatile trioxide, WO_3, and the silicide's inability to form a continuous protective scale at lower temperatures.

Another drawback of the silicide coatings is their inherent brittleness and inability to be formed after application. This means that parts have to be treated in their final form.

Stable oxides may protect— Some preliminary work is now underway on metallic and intermetallic coatings that can be treated to produce stable oxide surfaces on tungsten. In general, refractory oxides (except for magnesium oxide) do not have any unfavorable reactions with tungsten. Refractory carbides and nitrides, however, are much too reactive to be of any use.

At the present state of the art it is too early to say which oxides are best. Oxides of zirconium can be produced in a controlled atmosphere. Also, thorium oxide is unreactive up to its melting point (about 5600 F).

TABLE 3—LIFE OF PROTECTIVE COATINGS FOR TANTALUM

Coating	Application Method	Coating Thickness, mils	Maximum Life, hr			Substrate Hardening
			2200 F	2500 F	2700 F	
Aluminum	Hot Dip at 1800 F, Heat in Vacuum at 1700 F	2	>6	3.5	—	None
	Pack Cementation*, 16 Hr at 2000-2200 F	2-4	—	>7.5	>6	None
Chromium	Electroplating, Vapor Deposition	Nonuniform	—	—	—	—
	Pack Cementation at 1800-2400 F	0.1-0.7	0.5	0	—	Severe
Silicon	Vapor Deposition at 2370 F	1	0	0	—	—
	Pack Cementation at 2000-2400 F	2-5	>6	>7	5-10	None
Aluminum Oxide + Glass	Flame Spray, Paint, and Sinter	5	0	0	—	Severe
Titanium	Pack Cementation at 2000-2370 F	0.2-0.5	1.5	0	—	None
Hafnium	Pack Cementation at 2200 F	0.3	2	0	—	—
Zinc	Vacuum Distillation, Hot Dip	—	Coatings mechanically adherent only and not oxidation resistant at 1700 F			

*Pack mixtures contained 75% (by vol) Al_2O_3 filler, 25% coating element, plus halide carrier. Packs heated in argon, generally for 16 hr.
Source: Battelle Memorial Institute.

Acknowledgments

Assistance of personnel from the following companies is gratefully acknowledged:
Aeronautical Systems Div., Air Force Systems Command
Battelle Memorial Institute
Martin Co.

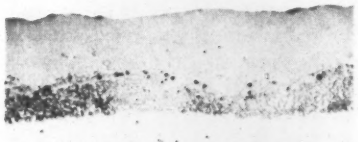
New Metallic Diffusion Coatings

now under development can protect surfaces against oxidation at temperatures to 2300 F. Coatings can be applied to a wide variety of ferrous and nonferrous alloys, including nickel and cobalt-base superalloys.

■ Previous articles in this magazine have shown how conventional diffusion treatments such as chromizing and aluminizing can be used on irons and steels to solve high temperature problems, and how sherardizing (zinc) and siliconizing can be used to protect metals against corrosion and wear. In addition to these four basic diffusion treatments, coatings specialists are now developing new diffusion coatings. The previous article discussed one group of diffusion coatings—the silicates—that shows much promise for the refractory metals. Many of the new coatings that will be discussed here can be used on ferrous as well as nonferrous alloys.

Two new coatings

High oxidation resistance for a wide variety of nonferrous and ferrous alloys can now be obtained with two new diffusion coatings based on nickel-aluminum and iron-aluminum and developed by Haynes Stellite Co. The coatings are applied by a process similar to pack carburizing to provide an intimate bond (as shown in the accompanying photomicrograph, Fig 4), and good resistance to spalling, chipping, thermal shock and flame erosion.



Haynes Stellite Co.

***Typical structure** of diffusion coating shows intermediate layer that forms when topcoat and base metal alloy during heating.*

Many metals can be coated—Coatings based on nickel-aluminum (designated Haynes diffusion coating No. C-3) are intended for use on nickel-base alloys. Coatings based on iron-aluminum (Haynes diffusion coating No. C-6) can be used over a wider range of metals, including cobalt, nickel and iron-base alloys.

Specific alloys that can be diffusion coated include the nickel-base superalloys (e.g., Hastelloy alloys B, C and X), nickel-base precipitation hardening alloys (GMR-235 and Haynes alloy No. 713C), cobalt-base superalloys (Haynes alloy No. 152 and Haynes Stellite alloy No. 31), many stainless steels (including austenitic, ferritic and precipitation hardening), some copper alloys, and carbon steel.

Coatings are applied by heating the alloys up to 2000 F up to 24 hr. Thickness of the coatings is relatively little, usually from 1 to 6 mils, and since the reaction is by inward diffusion there is only a very small increase in thickness. The coatings form uniformly over entire surfaces, including the inside of pipes, external and internal radii, and corners, as well as uniform flat and cylindrical areas.

Misco Precision Casting Co.

***Vapor diffusion** in a reducing atmosphere at high temperature produces metallic coatings on many medium size parts in one operation.*

Coatings reduce the oxidation weight loss—Table 4 shows how the coatings can improve the oxidation resistance of three typical nickel, cobalt and iron-base superalloys. Note that diffusion coated alloy No. 713C (one of the most oxidation resistant nickel-base super-alloys in use today) shows a weight loss 1/16 that of uncoated material when exposed to 2300 F for 100 hr.

The treatment also greatly increases the thermal shock resist-

ance of the nickel and cobalt-base superalloys. For example, alternate heating and cooling of the alloy with an oxyacetylene flame and air blast can produce considerable erosion after only 50 cycles. In contrast, a nickel-aluminum diffusion coating on the alloy is unaffected after 1000 cycles. Similarly, an iron-aluminum coating on the cobalt-base superalloy is unaffected after 2000 cycles, as compared to uncoated surfaces which fail in 50 to 200 cycles.

The treatment, when used on these two superalloys, has little effect on their mechanical properties. Hot hardness and Charpy impact values at high temperatures show no significant difference between coated and uncoated specimens.

In general, tests show that the heating during diffusion has a minor effect on many alloys. However, time and temperature of the diffusion treatment itself could affect properties of alloys that are heat treatable, age hardenable or susceptible to grain growth. Such effects should be considered when using the diffusion treatment. Limited experience with some alloys has demonstrated that complete thermal treatment after coating is possible without effect on the coating.

TABLE 4—OXIDATION RESISTANCE OF DIFFUSION COATED ALLOYS

Temp, F	Time at Temp, hr	Condition	Wt Change, mg/sq cm
Nickel-Aluminum Over Nickel-Base Superalloy[a]			
2000	500	Uncoated	−3.3
		Coated	+0.37
2300	100	Uncoated	−49.2
		Coated	−3.1
2300	400	**Coated**	−45.7
Iron-Aluminum Over Cobalt-Base Superalloy[b]			
2000	500	Uncoated	−200
		Coated	+12.4
2300	20	Uncoated	Dest
		Coated	+1.1
Iron-Aluminum Over Alloy Steel			
1800	100	Uncoated	+262.5
		Coated	+7.5

[a]Haynes alloy No. 713C.
[b]Haynes alloy No. 152.

Pure Metal Coatings Reflect Heat Best

Vacuum deposited thin metal films must usually be used where high heat reflective is required. Heat reflectance coatings can be effective where temperature control is required (e.g., satellites), or where some temperature reduction is required in the medium temperature range. Unlike the diffusion coatings they cannot be used at very high temperatures. Aluminum reflective coatings, for example, are effective to 1200 F, and pure gold coatings to 1650 F. However, both coatings will resist short-time exposure to radiation from flames as hot as 5000 to 6000 F.

Plated-diffused coatings

The National Bureau of Standards, under the sponsorship of Wright Air Development Center, has developed a novel method for producing nickel-aluminum coatings that can extend the operating temperature range of many metals (see "Nickel-Aluminum Coatings Protect Metals up to 1830 F," M/DE, Nov '60, p 10). The coatings have proved effective on steel, nickel and molybdenum, and can probably be used on other metals. In air at 1020 and 1830 F, they have been found to oxidize at one-tenth the rate of nickel coatings of comparable thickness. They also have high resistance to corrosion.

The coatings can be produced in two ways:

1. In the first method nickel is electroplated on the base metal from a Watts-type bath and subsequently coated with aluminum from a fused salt solution at 1290 F. This high temperature also serves to diffuse the aluminum into the nickel as it deposits, thus forming the alloy.

2. In applications where the base metal cannot withstand this temperature, the aluminum is deposited from a fused salt bath at 320 F. The coating is then alloyed with the nickel by heating for a few hours in air at 930 to 1110 F.

Other new diffusion coatings

Many thermal protective coatings can be applied by a proprietary diffusion process recently introduced in this country by Misco Precision Casting Co. Originally developed in Germany by Deutsche Edelstahlwerke A. G., the coatings are especially designed to increase the high temperature oxidation resistance and thermal fatigue properties (as well as the corrosion and abrasion resistance) of many metals and alloys. The developers claim that a wide variety of coatings (including chromium) can be deposited but are not yet in a position to reveal composition details. The coatings are reportedly not of the nickel-aluminum or iron-aluminum type described above.

High temperature resistance is claimed for many base metals, including nickel and cobalt-base alloys. Coated cobalt-base alloys are said to be usable up to 2200 F, and nickel-base alloys up to 1800 F. The coatings also provide improved fatigue resistance at high temperatures. One nickel-base alloy (Inco 100) fatigue tested at 1500 F has withstood over 34,000 cycles—30% more than an uncoated alloy. Intergranular corrosion of coated nickel-base alloys in sulfur-bearing gases at high temperatures is also markedly reduced.

Coated low carbon steel has also been found to withstand high temperature service. In one test, parts exposed to 1500 F for 100 hr experienced less than 1% of the oxidation of uncoated metal.

The process gives completely uniform coatings of reproducible thickness. Danger of chipping, peeling or spalling is negligible because the coatings are continuous, nonporous and integral with the base metal. Also, the diffusion mechanism permits coatings to be applied to irregular and inaccessible areas such as crevices, undercuts, blind holes and joints.

Ablative Coatings

are being used in several aerospace applications to protect metals against intense heat for short periods. In many cases coating selection has to be based on "cut-and-try" methods because adequate test data are lacking.

by Dr. Ray L. Hauser, *Hauser Research & Engineering Co.*

■ The principles of ablation, so successfully used with plastics nose cones and rocket nozzles, are now being adapted to relatively thin, adherent coatings to protect metals (and even some nonmetallics) against high temperatures. The coatings are especially designed to: 1) protect lightweight, low temperature alloys under short-time, intense heating conditions where high temperature alloys would ordinarily be used; and 2) extend the operating temperature range of high temperature alloys. They can be used on:

- Missile surfaces to minimize heating effects on transition sections during ascent.
- Ground hydraulic, electrical and structural components during launch.
- Liquid and solid propellant engines and motors.
- Other areas where aerodynamic or flame heating is a problem.

How the coatings work

Ablation can be broadly defined as the absorption of heat during the thermal degradation and erosion encountered with high velocity, high temperature gas flow. Actually, ablative coatings are not all purely ablative since some also protect through a combination of heat blockage and insulation mechanisms. Nevertheless, engineers have found it useful to refer to ablative coatings as a group rather than separate them into coatings with different heat absorbing or heat blocking mechanisms such as pure ablation, pure sublimation, decomposition, dehydration and intumescence. Normally, most of these mechanisms are at work in an ablative coating system. For example:

Ablation itself is the thermal decomposition of high polymers into low-molecular-weight gaseous products and a porous carbon char. Heat is absorbed because the decomposition is endothermic. Decomposition of the polymer does not usually occur at constant temperature, so the decomposition rate is apt to vary with temperature in accordance with the Arrhenius equation. Similarly, the heat absorbed per unit weight of material is not constant, but depends mainly on the rate of heat transfer into the material. The minimum heat flux required to start ablation may vary from 100 to 2000 Btu per sec-sq ft (see "Ablation, Heat Sink and Radiation: Materials That Make Them Work," M/DE. Mar '61, p 114).

Sublimation is a physical phenomenon that can absorb large quantities of heat. In sublimation the transition of a material from a solid to a gaseous state absorbs heat (the "heat of sublimation"). The heat of sublimation and the sublimation temperature are less dependent on heat flux and environmental pressure than are the ablative decomposition effects of polymers. For this reason sublimation materials can be used to obtain thermostatic control, i.e., cooling at a fairly constant temperature. Because sublimation is relatively independent of heat flux, it has a major advantage over pure ablation in some applications.

Few sublimative materials can be applied directly as coatings; they have to be formulated like paints. Finely divided particles of sublimative chemicals are dispersed in resinous binders (with or without solvents) and are applied to metals in liquid or mastic form. Drying and/or crosslinking of the resin binder provides an adherent, durable coating containing a high concentration of heat absorbing materials.

Decomposition refers to the mechanism by which materials absorb heat by chemically decomposing. As used here the term does not include the ablation of high-molecular-weight polymers but is restricted to inorganic chemicals such as ammonium or carbonate salts and hydrates (e.g., $MgCl_2 \cdot H_2O$) and some organic chemicals. Many of these chemicals decompose endothermically at a fairly definite temperature. Magnesium chloride, for example, dehydrates at 244 F and is accompanied by a heat absorption of 1500 Btu per lb of water removed.

Ablative coatings incorporating water-soluble pigments of sublimation or decomposition materials

suffer a slight processing disadvantage in that a topcoat is usually required to prevent dissolution or efflorescence of the materials after application. Also, although the sublimation and decomposition types of ablative coatings can provide very good heats of ablation (heat absorbed per pound of material removed) at low temperatures, they do leave a small amount of undecomposed resin binder behind on the surface. A residue is left by practically all ablating materials (solid parts as well as coatings) except thermoplastics such as Teflon and polyethylene. This residue produces a weight penalty, but an extremely small one when compared to the weight that might be required for additional heat absorbing materials, i.e., a heat sink.

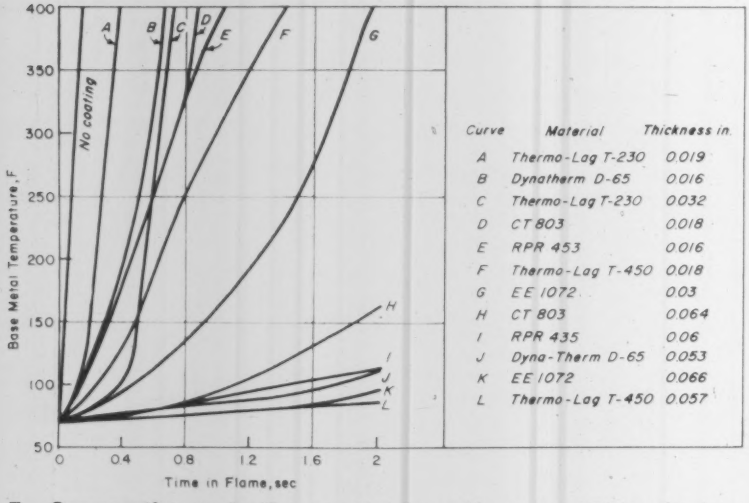
Intumescence is a heat blocking mechanism: the swelling of a coating into a thick, foamy mass with low thermal conductivity. It is produced in materials such as borax-type chemicals in which the water of hydration is vaporized, absorbing heat and at the same time foaming the material into a glassy mass.

An intumescent coating is most useful where flow velocities are fairly low. It is usually thick and weak and, because of its roughness, may blow away more easily than a smoothly ablating or decomposing type of surface.

As mentioned in an earlier article ("Five Ways to Control High Heat Flux," M/DE, Feb '61, p 101), the mechanical effects that occur during ablation, sublimation, etc., can play a major part in coating effectiveness. Subsurface vapor formation can cause spalling, sloughing or shearing to throw off chunks of otherwise protective material. Thus, the binder and pigment must have compatible chemical, physical and thermal characteristics. Achieving this compatibility is a difficult task and is the reason why the formulation of ablative coatings is often tedious and empirical.

TABLE 5—COMMERCIAL ABLATIVE COATINGS

Tradename	Manufacturer	Type	Resin System	Heat of Ablation, Btu/lb	Heat Flux, Btu/sec-sq ft
Avcoat I	Avco Corp.	Ablation	—	4,340	1,375
CT 803	CTL Div., Studebaker-Packard Corp.	Ablation	Phenyl-silane soln	—	—
CT 804	"	"	"	—	—
T-230	Emerson Electric Mfg. Co.	Sublimation	Epoxy soln	6,500	20–190
T-450	"	"	"	—	—
T-50	"	"	"	15,000	500–900
EE 1072	Empire Coatings & Chemical Co.	Sublimation	Epoxy-polyamide soln	—	—
RPR 435	Raytheon Co.	Ablation	Epoxy soln	—	—
RPR 438	"	"	—	—	—
PK-4606	Dyna-Therm Chemical Corp.	Ablation	Epoxy-polyamide	—	—
D-65	"	Intumescence	Polyurethane soln	—	—



5 Comparative protection *provided by coatings over 0.05-in. aluminum sheet exposed to combustion gases at 6000 fps and heat flux of about 130 Btu per sec-sq ft. Note how thinner coatings produce significant drop in heating rate. (Data courtesy Martin Co., Denver Div.)*

A look at available coatings

A list of important commercial ablative coatings is given in Table 5. Note that because of their complex (and often proprietary) composition the coatings are referred to by tradename, rather than chemical type. The cost of these coatings varies over a wide range —from $2 to $40 per lb of solids. Their cost will undoubtedly decrease as competition increases. Keep in mind that the cost of application may also be high because some of the coatings are difficult to apply (some, however, are easily applied).

It is apparent from the table that there is a lack of quantitative information on the properties and performance of ablative coatings. This may be one of the reasons behind the slow acceptance of the materials. Ablation tests simulating reentry conditions are very expensive and few suppliers can afford them. Thus, very few data under simulated operating conditions are available.

The Martin Co. has provided an interesting comparison of ablative coatings in a single test environment: combustion gases at 6000 fps and a heat flux of about 130 Btu per sec-sq ft. The relative performance of coatings is shown in

Fig 5; keep in mind that the relationship shown could change radically under other conditions. Nevertheless it is apparent that all of these coatings provide very definite cooling.

Take one for example. Bare, uncoated aluminum exposed to the gases reached 400 F (the temperature at which aluminum rapidly loses strength) after only 0.14 sec. In contrast, when protected with a coating such as Thermo-Lag 450, the aluminum took 1.4 sec to reach the same temperature. The weight of the coating was 18% the weight of the aluminum panel, yet it increased the time to reach the critical temperature by 900%. Thus, the coating was 50 times as effective as an equivalent weight of aluminum in keeping temperature below 400 F.

Current applications

A survey of the ablative coatings listed in the table shows that they are being successfully used in a fairly wide range of applications:

Avcoat I ablative coatings (Avco Mfg. Corp.) have been used on rocket nozzle and motor exteriors and to protect metal surfaces during aerodynamic heating. They can be applied in thin coats by spraying, brushing or troweling, and harden in 2 to 4 hr at room temperature.

CT 803 and 804 coatings (developed by CTL Div., Studebaker-Packard Corp., and distributed by U. S. Polymeric Chemicals, Inc.) consist of phenyl-silane resins plus proprietary refractory fillers. Three sections of the aluminum nose structure of the successful Juno II moon vehicle were coated with 0.08 in. of CT-803: specifically, the fore cone, the cylindrical section (except for telemetry windows), and the aft cone frustrum (see Fig 6). Although not designed for mechanical abuse, the coating withstood the vibration of fastening 1500 rivets within the structure.

Dyna-Therm D-65 coatings (Swedlow, Inc.) are unique among ablative coatings because of their elastomeric properties. The coatings contain a polyurethane binder with an elongation of 200% and can be used on flexible umbilical cables (see Fig 7) and ground support equipment that is flexed (e.g., Atlas, Titan and Pershing equipment). Protection is provided through boron and phosphorus compounds which provide an intumescent heat blocking mechanism.

Flameastic-700, another coating available from the same company, was one of the first ablative coatings ever developed and has been used extensively since 1955 to protect rigid ground support equipment in rocket installations, as a lining for rocket booster tubes, and for numerous commercial applications.

Thermo-Lab T-230 and T-500 (Emerson Electric Mfg. Co.) are probably the most versatile series of ablative coatings developed to date. They can be used for thermostatic temperature control over the range from 230 to 2200 F. Successful applications include nose cones, guidance fins and rocket nozzles for the Little Joe space capsule, and the Polaris, Minuteman and Honest John (see Fig 8) rockets and missiles.

EE-1072 (Empire Coatings & Chemical Co.) is a fairly new and unpublicized ablative coating that is very easy to apply. Although its thermal properties have not been quantitatively evaluated its performance relative to other coatings (see Fig 5) appears to be promising.

RPR 435 and 438 coatings (Raytheon Corp.) provide protection through ablation and sublimation mechanisms. They can be applied by spraying or brushing. Still in the development stage, they have not yet been proved in missile applications.

Acknowledgments

Assistance of personnel and literature from the following companies is gratefully acknowledged:

Avco Corp., RAD Div.
Dyna-Therm Chemical Corp.
Emerson Electric Mfg. Co.
Empire Coatings & Chemical Co.
Martin Co., Denver Div.
Raytheon Co., Aero Weapons Div.
Swedlow, Inc.
U.S. Polymeric Chemicals, Inc.

CTL Div., Studebaker-Packard Corp.

6 Nose assembly of Juno II *gets ablative coating CT-803 to protect aluminum from excessive heat. Coating is applied to hot metal to produce simultaneous heat cure.*

Swedlow, Inc.

7 Umbilical connector *after rocket firing. Note how metal casing (center) was melted by blast, whereas rubber and plastics portions coated with D-65 remain flexible and undamaged.*

8 Nozzle of Honest John *immediately after recovery and still buried in soil. Nozzle of this solid propellant missile is coated externally with Thermo-Lag T-500, a sublimation-type coating, to cool interior structure. Coating is applied in waffle pattern to prevent spalling when subliming gases pass through.*

Emerson Electric Mfg. Co.

What About Other Ceramic Coatings?

Engineers are now using • a strippable porcelain enamel • special emittance coatings • two other coatings that solve tough problems

■ Since our last comprehensive report on high temperature coatings a little over three years ago ("Porcelain Enamels and Ceramic Coatings," M/DE, July '58, p 103) there have been relatively few advances in high temperature porcelain enamels and enamel-refractory oxide coatings. Lack of development on these materials stems from the fact that engineers have completely passed over the temperature range of 1500 to 2200 F where conventional high temperature porcelain enamels and enamel oxide mixtures predominate.

Nonetheless, these materials are still eminently suitable for protecting metals below 2200 F (the materials are limited to temperatures near their smelting point). There is even hope that temperature limits can be pushed as high as 3000 F if high temperature enamels can be loaded up with enough refractory oxides. And, as the following paragraphs show, ceramic coatings may expand into new product or processing areas within the intermediate temperature range.

New strippable porcelain enamel

Although few new high temperature enamels and oxide mixtures are being developed, one new and promising area has opened up for such coatings. Temporary coatings are now being developed to protect metals from oxidizing during heat treatment at temperatures of 1900 to 2400 F.

These coatings, called "heat treatment protective coatings," may permit the elimination of controlled atmospheres during heat treatment. They are still in the experimental stage and have been used in some plant trials. Most work right now is concentrated on protecting stainless steels, but there does not appear to be any reason why such coatings cannot be used on other metals.

The coatings are applied much like regular porcelain enamels but differ in that they can be easily removed after the base metal has been heat treated. Mechanical removal of the coatings is preferred; this could be followed with a chemical treatment. In some cases secondary oxides will form on the metal but this is not necessarily a disadvantage.

Controlling heat emittance

Many inorganic coatings can now be formulated with special emittance materials to control high temperatures. Except for nickel and chromium oxides, materials with controlled heat emittance properties are not usually used alone but are usually combined with other materials to obtain a combination of properties. Thus, emittance materials are not usually doctored so that they will be suitable for high temperature use but are usually added to basic oxidation resistant coatings. In such cases the basic coating provides high temperature oxidation resistance and the emittance material helps to lower temperature of the base metal, often by as much as several hundred degrees.

Reentry is a good example of where both high emittance and high oxidation resistance are needed. Incorporating high emittance materials such as chromic nickel oxide or chromic oxide in the ceramic coating helps get rid of the heat fast and the oxidation resistant materials in the coating prevent destructive oxidation of the base metal.

Other coating developments

In addition to all the ceramic and inorganic coatings previously discussed, two unusual coating systems have been developed for solving unusual heat problems:

▸ B. F. Goodrich Co. has now patented an inorganic, slightly alkaline water-base coating which is especially compatible with rocket fuels. The coating is designed to be used on the inside surfaces of booster cases and rocket motors to insulate steel from high velocity flames at 2000 to 5000 F for periods of 1 to 10 sec. The material comes in the form of a paste which is diluted with water for spraying consistency. It is noninflammable and odorless and can be used to eliminate the paper between the case and the propellant.

▸ American Thermocatalytic Corp. has developed a series of high temperature materials known as Astrocerams which can be used as high temperature coatings, as well as sealants and adhesives. These proprietary materials are mixtures of oxides and silicates available in two temperature ranges and types. Protection up to 4300 F is claimed for an air drying type, and a useful limit of 5300 F is claimed for a second type which must be fired.

Acknowledgments

The author would like to express his appreciation for the assistance of personnel and literature from the following companies:
American Thermocatalytic Corp.
B. F. Goodrich Co.
Pemco Corp.

Copyright, Reinhold Publishing Corporation, 1961. All rights reserved. Reprints of this Special Report are available at 35c each until supply is exhausted. See page 172 for complete list of available reprints. Write for quotations on quantities of 100 or more. Address Reader Service Dept., MATERIALS IN DESIGN ENGINEERING, 430 Park Ave., New York 22, N. Y.

first in silicones

Dow Corning

SILICONE NEWS

for design and development engineers • No. 88

FLUOROSILICONE Advantages

- Much improved solvent resistance
- Better lubricity
- Increased chemical resistance
- Higher dielectric constant
- Good LOX resistance

This is Dr. Ogden Pierce, head of Dow Corning's fluorine research program, as he described the major features of fluorosilicones to a recent conference of editors representing leading technical and trade publications. Dr. Pierce is also Chairman of the Fluorine Chemistry Subdivision of the American Chemical Society. This introduction to the fluorosilicones is a brief summary of Dr. Pierce's comments to the editors.

Meet the FLUOROSILICONES

The fluorosilicones are a new family of semi-inorganic polymers that offer a high order of solvent resistance, markedly improved lubricity, and all the more desired properties of standard silicone materials.

Chemically, most commercial silicones have methyl groups attached to the siloxane polymer. Fluorosilicones are produced by substituting fluoroalkyl groups for most of the methyl groups.

Fluorosilicones are available in four different physical forms: fluids, greases, compounds and rubbers. While the rubber-like materials were first introduced five years ago, the other fluorosilicones are completely new products.

They are, however, already advanced beyond the "experimental" stage, and pilot plant quantities are being produced for several military and industrial applications in which these new materials have proved to be effective and economical.

Suggested Uses

Greases — as all-temperature lubricants that provide lasting lubrication in the presence of solvents and chemicals.

Fluids—as defoamers of solvents and oils; as lubricants, damping media, flotation fluids and plasticizers in areas where solvent resistance is essential.

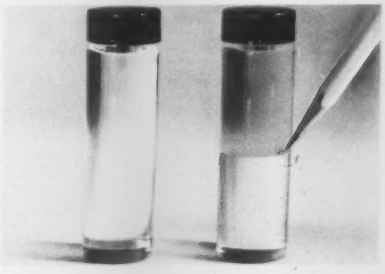
Compounds—as greaselike lubricants for valves, rubber O-rings, grommets and mounts in contact with liquid fuels, solvents and chemicals.

Rubbers—demonstrate outstanding resistance to solvents, jet fuels, oils and fluids over an operating temperature range of —80 to 500 F.

Solvent resistance

Fluorosilicone fluids are insoluble in most solvents (except the ketones and esters) and are incompatible with most petroleum oils.

In demonstration at right, both vials had been half-filled with perchloroethylene. A standard silicone fluid was then added to vial on left, and one of the new fluorosilicone fluids was added to vial on the right. You see both vials a few moments after they were well shaken and then allowed to stand at rest. Note how the standard silicone fluid has been completely dissolved by the perchloroethylene, while the fluorosilicone fluid separated quickly and completely as indicated by the meniscus in the vial at right.



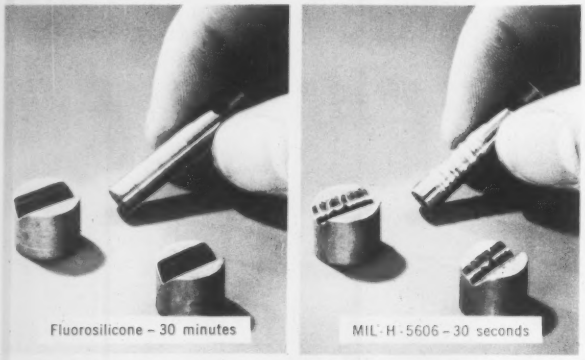
For technical information about all fluorosilicones, use coupon on next page or circle reference number **241** on reader service card

Meet the FLUOROSILICONES

Improved lubricity

That fluorosilicones have exceptional lubricity has been verified by both Falex tests and field experience.

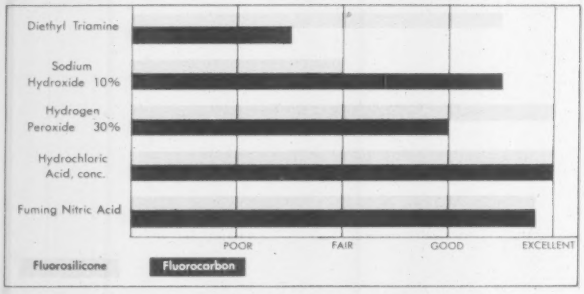
In the Falex test, a small shaft under load is rotated between two steel vee-blocks while immersed in the test lubricant. In the left photo you see shaft and vee-blocks tested in one of the new fluorosilicone fluids. Test time was 30 minutes; test load — 350 pounds. The shaft and blocks in the right hand photo were tested in standard MIL-H-5606 Hydraulic type oil. Test load was 350 pounds; however, test time was only *30 seconds!* Note the fluorosilicone set shows little scoring and wear even after 30 minutes testing.



Chemical resistance

The good chemical resistance of fluorosilicones is illustrated by the bar graph at right.

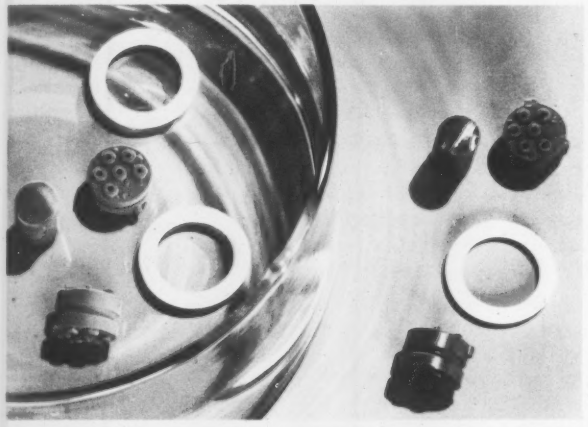
In determining these ratings, glass slides coated with a Dow Corning fluorosilicone compound were immersed to *half* the coating depth for 16 hours in diethyl triamine; 30% hydrogen peroxide; fuming nitric acid; concentrated hydrochloric acid, and 10% sodium hydroxide. Only the 10% sodium hydroxide exhibited any appreciable effect on the fluorosilicone compound.



Elastomers, too

Fluorosilicone rubbers, named Silastic® LS, have thoroughly proved their effectiveness in a variety of military and industrial applications requiring solvent-resistance, inertness and serviceability at both high and low temperatures. A look at the properties will explain why fluorosilicone rubbers have enjoyed rapid acceptance.

PROPERTIES	
Hardness, Shore A	50-65
Tensile Strength, psi	800-1000
Elongation, percent	150-170
Serviceable Temperature Range	—80 to 500 F
Fuel Resistance (JP-4), percent change after 30 days immersion	
Durometer	—5
Tensile Strength	—31
Volume	+10
Weather Resistance, after 31 months (3549 sun hours) at Florida Test Station — no visible effect.	



Silastic LS, fluorosilicone rubber parts at left show negligible swell after prolonged immersion in JP-4 fuel. Compare size with identical parts at right which were not immersed in the fuel.

Dow Corning Corporation, Dept. B223, Midland, Michigan

Please send me technical data about all fluorosilicones

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE _____ STATE _____

SILICONE NEWS is published for design and development engineers by

first in silicones

Dow Corning

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON D.C.

CANADA DOW CORNING SILICONES LTD. TORONTO OVERSEAS DOW CORNING INTERNATIONAL S.A. ZURICH

For technical information about all fluorosilicones, use coupon on this page or circle reference number 241 on reader service card

FILE FACTS

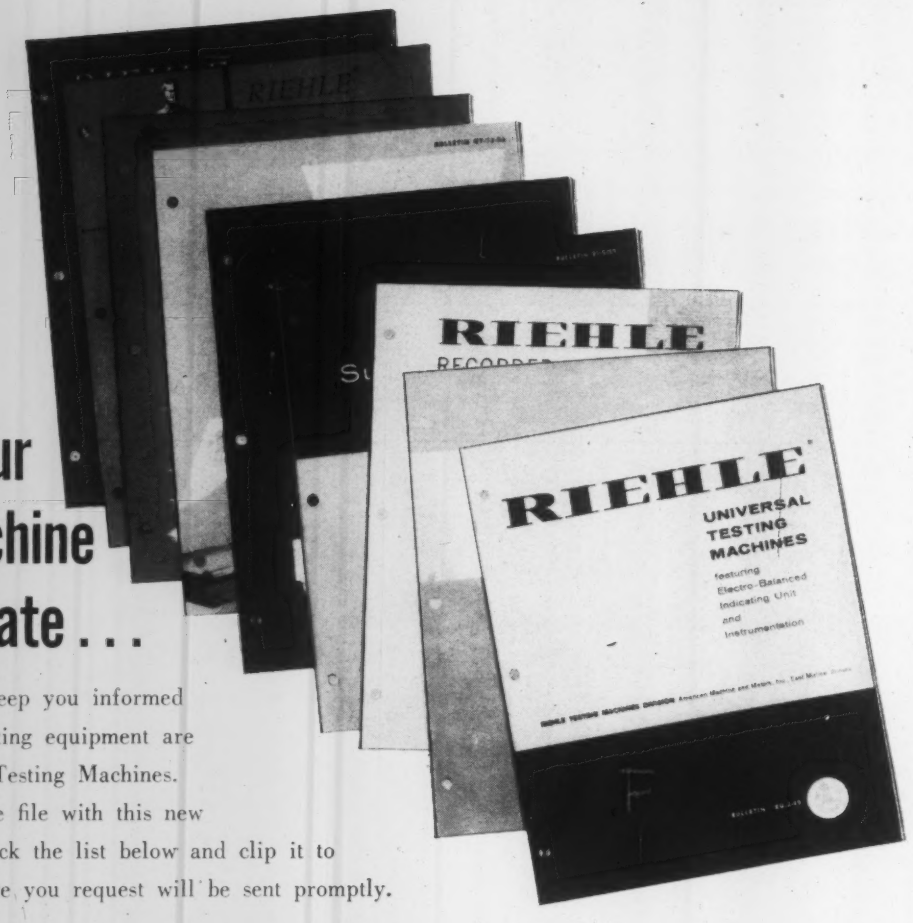
Corrosion Resistance of Electroless Nickel Coatings

Medium	Temp, F	Aeration		Immersion		Coating Heat Treat		Corr Rate, mil/yr
		Yes	No	Tot	Part	Yes	No	
SUITABLE								
Acetaldehyde	150	X			X		X	0.02
Acetone	Room		X	X			X	0.003
Acrylonitrile	150	X		X			X	0.016
Alkyd Resin	120	X			X		X	0.05
Amine Resin	120	X			X		X	None
Ammonium Sulfide	120	X			X		X	0.15
Ammon Sulfide Thiocyanste	Room		X	X			X	0.171
Amyl Acetate	Room		X	X			X	0.0019
Amyl Chloride	Room		X	X			X	0.013
Beer	45		X	X		X		0.0078
Benzol	Room		X	X			X	0.0016
Benzyl Acetate	Room		X	X			X	None
Benzyl Alcohol	Room		X	X			X	0.0036
Black Liquor Skimmings	Room		X	X			X	0.01
Boraxo Soln Sat'd	Room		X	X			X	0.12
Calcium Chloride Soln, 48.5%	Room		X	X			X	0.02
Caprolactam Monomer	185	X			X		X	0.03
Caprylic Acid	150	X			X		X	0.06
Carbon Disulfide	Room		X		X		X	None
Carbon Tetrachloride	Room		X	X			X	None
Cetyl Alcohol	160		X	X			X	None
Cobalt Linoleate	Room		X	X			X	None
Cresylic Acid	Room		X	X			X	None
Detergent Soln, 5% Tide	Room		X	X			X	0.037
Dibutyl Phthalate	Room		X	X			X	None
o-Dichlorobenzene	150	X			X		X	0.17
p-Dichlorobenzene	250		X		X		X	0.13
Diphenyl	Molt		X	X			X	0.009
Ethyl Alocohol	Room		X	X			X	0.0065
2-Ethyl Hexoic Acid	150	X			X		X	0.02
Ethylene Dibromide	150	X			X		X	0.107
Ethylene Glycol	Room	X		X		X		0.025
Formaldehyde	Room		X	X			X	0.15
Gasoline	Room		X	X			X	0.022
Insectisol	Room		X	X			X	0.008
Lactic Acid, 80%	Room	X		X		X		0.145
Methyl Alcohol	Room		X	X			X	None
Naphtha, Odorless	Room		X	X			X	None
Naphthenic Acid	150	X			X		X	0.02
Nitration Toluol	150	X		X			X	0.023
Oleic Acid	Room		X	X			X	0.012
Orange Juice, Canned	Room		X	X			X	0.013
Pelargonic Acid	250		X	X			X	0.01
Perchloroethylene	150	X			X		X	0.15
Petroleum (white oil)	Room		X	X			X	None
Petroleum (sour crude)	Room		X	X			X	None
Polyester Resin	120	X			X		X	None
Polyvinyl Acetate	150	X			X		X	0.05
Refinery Brine Sol	Room		X		X		X	None
Rosin Size	210	X		X		X		None
Sodium Carbonate, 10%	Room		X	X			X	None
Sodium Hydroxide, 73%	250	X			X		X	0.07
	250	X		X			X	0.07
	250	X		X		X		0.09
	250		X	X			X	0.01
	250		X	X		X		0.03
Sodium Hydrosulfide, 40%	Room	X		X			X	None
Sodium Sulfide	200		X		X		X	0
Sodium Sulfhydrate	120	X			X		X	0.14
Sorbitol	150	X			X		X	0.1
Stearic Acid	158		X	X			X	0.02
Sugar, Liquid	Room		X	X			X	None
Tall Oil (crude)	100	X			X		X	0.03
Tall Oil (fatty acid)	150	X			X	X		0.04
Tall Oil (refined)	Room		X	X			X	0.017
Tall Oil (rosin)	320		X	X			X	None
Terpinyl Acetate	120		X	X			X	0.007
Trimethylphosphite	125	X			X		X	0.004
SUITABLE (Cont'd)								
Urea (sat'd soln)	Room	X		X		X		None
Urea (25% soln)	Room	X		X		X		None
Water (deionized)	180	X		X			X	None
Water (distilled)	Room		X	X			X	0.029
Wine, Sherry[a]	Room		X	X		X		0.0041
MARGINALLY SUITABLE (under some conditions can be suitable)								
Ammoniated Ammonium Nitrate	Room		X	X			X	0.31
Ammonium Chloride Soln	Room		X	X			X	0.23
Aniline Hydrochloride, Sat'd	Room		X	X			X	0.468
Beer	45		X	X			X	0.217
Brine, 38% Salts	167		X		X		X	0.66
	215		X		X		X	0.48
Butyraldehyde	150	X		X			X	0.2
Chloral, 90%	150	X			X		X	0.3
Citric Acid, 5%[b]	Room	X		X			X	0.0744
Lactic Acid, 45%	Room		X	X			X	0.3
Lactic Acid, 80%	Room	X		X			X	0.704
Lemon Juice, Canned	Room		X	X			X	0.23
Sodium Chloride, 3%[a]	Room		X	X		X		0.04
Sodium Cyanide, 5%	Room		X	X			X	0.52
Sodium Formate Slurry	150	X		X		X		0.3
Sodium Sulfhydrate	250		X		X		X	0.48
Sorbitol	230		X	X			X	0.2
Tall Oil (crude)	350		X	X			X	0.2
Tall Oil (fatty acid)	350		X	X			X	0.2
Trichloroethylene	150	X			X		X	0.20
Wine, Sherry[a]	40		X		X		X	0.377
NOT SUITABLE								
Acetic Acid, 5%	Room	X		X			X	5.95
Alum	150	X		X			X	Severe
Ammonium Hydroxide, 30% NH_3	Room		X		X	X		Severe
Ammonium Nitrate, 63%	Room		X	X		X		Severe
Ammonium Phosphate, 5%	Room	X		X			X	Severe
Ammonium Sulfate, 5%	Room	X		X		X		Severe
Barium Chloride, Sat'd	Room		X	X			X	Severe
Benzyl Chloride	Room		X	X			X	1.44
Bleach Liquor	Room		X	X			X	Severe
Boric Acid Soln	Room		X	X			X	Severe
Calcium Chloride Soln, 40%	200		X		X		X	Severe
3%	Room	X		X			X	Severe
Caprylic Acid	300		X	X			X	6
Chromic Acid, Sat'd	Room		X	X			X	Severe
Cyanamide, Liquid	Room	X		X			X	0.898
Dimethyldithithio-carbamate			X		X		X	Severe
2, 4 Dichlorophenol	160	X		X			X	10.9
2-Ethyl Hexoic Acid, Water Sat'd	150	X			X		X	1.6
Fluorophosphoric Acid	Room		X	X			X	Severe
Hydrochl Acid Soln, pH 1.5-4[c]	—	—	—	—	—	—	—	Severe
Monochloracetic Acid Soln	Room		X	X			X	Severe
Nitric Acid	Room		X	X			X	Severe
Nitrogen Fertilizers	150	X		X		X		4.7
Phosphoric Acid, 85%	140		X	X			X	Severe
Polyvinyl Acetate	200		X	X			X	2.0
Sodium Chloride, 3%	Room	X			X		X	Severe
Sulfuric Acid, 1% Conc[c]	—	—	—	—	—	—	—	Severe
Vinegar	Room		X	X		X		Severe
Wine, Cream Sherry	150	X			X	X		2.5
Wine, Dry Sherry	150	X			X	X		3.0
Zinc Ammonium Chloride	230		X	X		X		Severe

[a]Corrosion rate very sensitive to aeration. [b]Turns green. [c]Under numerous test conditions.
Source: Kanigen Div., General American Transportation Corp.

EASY WAY

to bring your testing machine file up to date...



New bulletins* to help keep you informed about today's modern testing equipment are being offered by Riehle Testing Machines. To up-date your reference file with this new technical information, check the list below and clip it to your letterhead. Literature you request will be sent promptly.

CHECK BULLETINS WANTED — MAIL TODAY

- ☐ *Riehle Recorder and Accessories plus Supplement
- ☐ *Riehle Universal Testing Machines Featuring Electro-Balanced Indicating Unit and Instrumentation
- ☐ Creep and Stress-Rupture Testing Machines
- ☐ An Axial Loading Creep Machine
- ☐ *The Riehle-Los Hydraulically Actuated Fatigue Testing Machine
- ☐ *Measuring Instrumentation Components and Complete Systems for Force and Distance
- ☐ Construction Materials Testing Machines and Accessories
- ☐ Torsion Testing Machines
- ☐ Glossary of Terms Representing Mechanical Properties and Tests
- ☐ Brinell Hardness Testers
- ☐ Vickers Hardness Testers
- ☐ Portable Hardness Testers for Rockwell Readings
- ☐ Hardness Conversion Chart for Hardened Steels
- ☐ Impact Testing Machines
- ☐ The Charpy Impact Machine and Procedure for Inspecting and Testing Charpy V-Notch Impact Specimens
- ☐ Cable and Wire Testers
- ☐ *Calibration Catalog
- ☐ Handsome wall plaque, reading: "One Test is Worth a Thousand Expert Opinions."™

Riehle® TESTING MACHINES

A DIVISION OF

American Machine and Metals, Inc.

EAST MOLINE, ILLINOIS

"One test is worth a thousand expert opinions"

Divisions of American Machine and Metals, Inc.

TROY LAUNDRITE MACHINERY • RIEHLE TESTING MACHINES • DEBOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS • NIAGARA FILTERS • UNITED STATES GAUGE • AUTOBAR • AUTOMATIC DEVICES • LAMB ELECTRIC COMPANY • HUNTER SPRING COMPANY GLASER-STEERS CORPORATION

For more information, turn to Reader Service card, circle No. 440

Price cuts on two vacuum melted superalloys have been announced by Allegheny Ludlum Steel Corp. Grade A-286 has been reduced to $1.28 per lb from $1.60 and Grade AL-901 to $2.10 from $2.60. The two high nickel alloys are sold in the form of forging billets.

A new supplier of polypropylene is Allied Chemical Corp.'s Plastics Div. The material is sold under the tradename Plaskon.

Meanwhile a 4¢-per-lb cut in the price of two polypropylene grades has been announced by Enjay Chemical Co., Div. of Humble Oil & Refining Co. New price is 42¢ per lb in 20,000-lb lots. The two grades are designed for long-term service at elevated temperatures.

Sintered molybdenum mill products have been added to Universal-Cyclops Steel Corp.'s line of refractory metal products. The mill products, available from the company's Refractomet Div., are supplied as sheets in thicknesses from 0.010 to 3/16 in. and as bars in diameters ranging from 1/16 to 2 in.

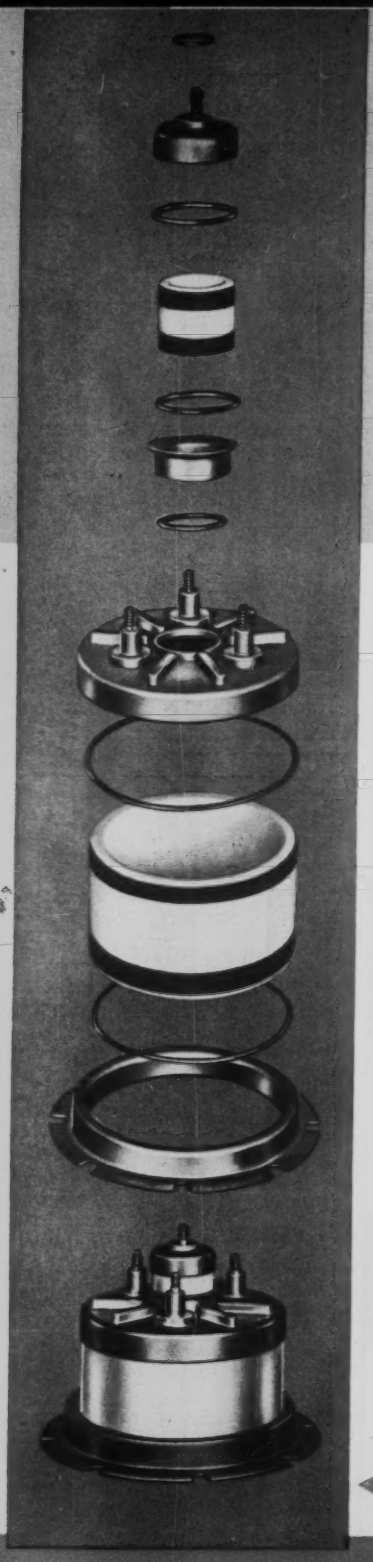
Price of a clear silicone potting and embedding resin has been reduced from $10.50 to $9.50 per lb by the Silicone Products Dept. of General Electric Co. The resin was introduced earlier this year (M/DE, Mar '61, p 188).

Beryllium metal tubing is no longer available from Superior Tube Co., according to a recent announcement. The company previously supplied hot extruded beryllium tubing produced by an English firm (M/DE, June '60, p 228).

A price increase on cellulose acetate molding compounds has been put into effect by Celanese Corp. of America. Price for translucent-colored compounds has been raised 4¢ per lb to 52¢ per lb in carload quantities. Opaque-colored compounds have been increased 6¢ per lb to 46¢. Also, two grades of cellulose acetate flakes have been increased 2¢ per lb.

Bright-annealed stainless steel sheets in widths up to 60 in. and in thicknesses up to 3/16 in. will be produced at new facilities now under construction at Republic Steel Corp.'s plant in Massillon, Ohio. The bright annealing facility, claimed to be the largest in the industry, is expected to be ready for start-up in late January. Annual capacity is estimated at 55,000 tons.

A price reduction on acrylic fiber has been announced by Chemstrand Corp. New price for 3.0 denier tow is $1.18 per lb, down 4¢ per lb; 5.0 and 8.0 denier staple and tow are now $1.14 per lb, down 8¢ per lb.



COMPLETE PRODUCTION

under ONE responsibility

ALSIMAG®

METALLIZED CERAMICS

AN integrated source, American Lava Corporation offers you 60 years of experience as custom producers of the widest range of technical ceramics from a single source, plus over 10 years of metallizing experience utilizing the several metallizing processes.

Here you have maximum range of choice in ceramic body selection, in metallize method selection, in metal part composition and configuration, and in facilities for inspection and testing. Centralized responsibility saves time, permits better control of quality.

Bulletin 612 is now available on request.

Bulletin 612 has 16 pages of metallizing details to help you find just the right combination for your application.

Bulletin 613 excerpts 4 pages of stock items in low and high temperature hermetic terminals.

FREE ON REQUEST

From basic ceramics through various metallizing, plating, brazing and testing procedures in one plant under one responsibility at American Lava.

A subsidiary of Minnesota Mining and Manufacturing Company

AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENN.
60TH YEAR OF CERAMIC LEADERSHIP

For service, contact American Lava representatives in Offices of Minnesota Mining & Manufacturing Co. in these cities (see your local telephone directory): Boston: Newton Center, Mass. • Chicago: Bedford Park, Ill. • Cleveland, Ohio • Dallas, Texas • Los Angeles, Cal. New York: Ridgefield, N. J. • Philadelphia, Pa. • St. Louis, Mo. • St. Paul, Minn. • So. San Francisco, Cal. • Seattle, Wash. Export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

For more information, turn to Reader Service card, circle No. 343

(cont'd from p 126)

STRENGTH OF ALUMINUM AT –423 F (1000 Psi)

Alloy & Temper ↓	Unwelded			Welded		
	Yield Str	Tensile Str	Notched Str	Yield Str	Tensile Str	Notched Str
5456	28.6	84.5	59.9	28.8	62.4	47.5
5456 H321	43.9	96.2	71.2	31.6	58.2	49.1
5083	25.2	85.2	59.3	26.7	64.6	49.8
5083-H113	41.8	90.0	72.8	27.1	64.2	51.5
5086	20.7	80.5	60.0	—	—	—
5086-H34	48.9	93.5	73.1	—	—	—
5454	23.9	81.1	61.8	—	—	—
5454-H34	41.0	87.8	75.8	—	—	—
304 SS (ann.)	55.9	228.0	162.0	69.2	132.5	150.0

Cryogenic Strength of Aluminum

New cryogenic strength data for the 5000-series aluminum-magnesium alloys have been determined by recent tests conducted at Battelle Memorial Institute.

As temperature was lowered to –423 F, an increase in strength occurred in the aluminum-magnesium alloys and in the type 304 stainless steel which was tested as a basis of comparison. No ductile-to-brittle transition occurred. Strength properties of welded and unwelded, notched and unnotched, tempered and untempered specimens are listed in the accompanying table.

In addition, the researchers found that:

- The sharp-notched strength of the alloys tested increased as temperature was reduced to –320 F. From –320 to –423 F it decreased slightly in some alloys and continued to increase in others. However, all of the notched specimens exhibited a greater strength at –423 F than at room temperature.
- Ductility was good for all of the alloys. Welded aluminum alloy 5083 showed better ductility at –320 F and –423 F than welded alloy 5456.
- Unnotched strength values of welded specimens were lower than those of the parent metal.
- The ratio of weld-to-parent metal strength at low temperatures was considerably higher for aluminum alloys than for the type 304 stainless steel in the unnotched state. When notched, the stainless steel ratio was higher.

Based on a report, "Tensile Behavior of Parent Metal and Welded 5000-series Aluminum-Alloy Plate at Room and Cryogenic Temperatures," by L. P. Rice, J. E. Campbell and W. F. Simmons of Battelle Memorial Institute.

Epoxy Takes 750 F in Filament Winding

A filament wound material, impregnated with an epoxy resin, has shown outstanding strength characteristics in recent tests at temperatures up to 750 F.

Previously acknowledged for use up to 500 F (see M/DE, Apr '60, p 17), Brunswick-Balke-Collender Co.'s epoxy resin VC-8359 used with E-type glass roving now appears even more attractive for two reasons. As indicated in the accompanying graphs, tests now indicate that this material has a tensile strength of

Makes Adhesives Bond Better

Bostik 4008 TIE COAT

This is an extra-ordinary primer and tie coat that locks itself to substrate, makes it possible to use common, low-cost adhesives for more critical bonding. Especially good when bonding plastic and rubber-like materials to metal.

This is how you benefit from Bostik Adhere*Ability* — the skill of making the most out of standard adhesives in place of exotic or expensive types. Your Bostik representative will help you specify the right Bostik number and provide application assistance.

Send for the new Bostik METHODS . . .

provides up-to-the minute data and information on the newest in adhesives, plus money-saving ideas and applications.

Whatever your adhesive need write: Bostik, BB CHEMICAL CO., Subsidiary of United Shoe Machinery Corporation, 784 Memorial Drive, Cambridge, Mass.

Bostik®

ADHEREABILITY

The Skill of Making Things Stick

For more information, circle No. 432

Easy Operation, Precision Measurements ...with Wilson "Rockwell" Hardness Testers

• No matter what your hardness testing requirements are, there's a Wilson Rockwell instrument to do the job easily and accurately. Long recognized as the world's standard of hardness testing accuracy, Wilson instruments on the production line and in the laboratory offer these advantages:

Accuracy—Each instrument is precision-built, with exact calibration, for consistently correct results.

Easy operation—Even an unskilled operator can get perfect readings. All controls conveniently grouped.

Long life—Simple design, rugged construction make Wilson instruments as durable as a machine tool.

Easy maintenance—Interchangeable mechanisms, with spindles mounted in oil-less bearings.

Complete line—Choose from the widest variety of instruments available, including semi and fully automatic models.

Wilson "Brale" Diamond Penetrators Each diamond is cut to an exact shape. A comparator check and microscopic inspection of each diamond assure perfect readings every time.

Write for details—Ask for Catalog RT-58. It gives complete information on the Superficial tester as well as on the full line of Wilson Rockwell hardness testers.

WILSON "ROCKWELL" HARDNESS TESTERS

Wilson Mechanical Instrument Division
American Chain & Cable Company, Inc.
230-E Park Avenue, New York 17, New York

ACCO
TRADE MARK

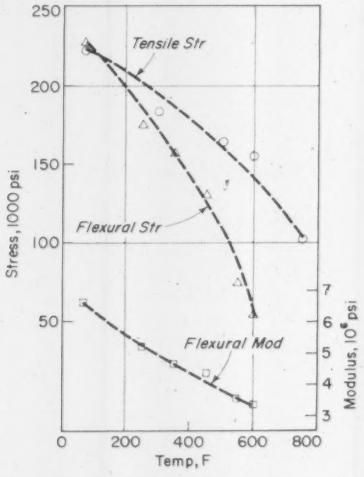
For more information, turn to Reader Service card, circle No. 371

103,760 psi at 750 F, and compressive strength of 23,970 psi and flexural strength of 55,040 psi at 600 F. The handling properties of this material have also been improved by the addition of an appropriate solvent to the basic mixture of resin and curing agent.

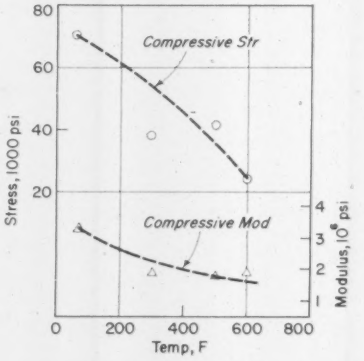
Test specimen design

Hoop tensile test specimens were fabricated by dip impregnation and circumferential winding on a 6-in. dia mandrel to a thickness of approximately 30 mils.

Cylinders used for compression tests were of three-ply construction. The inner and outer layers of rov-



***Tensile and flexural** properties of epoxy-glass filament wound structures . . .*



. . . and compressive properties.

THREE NEW PHENOLICS FROM GENERAL ELECTRIC

G-E 12985 **This new General Electric compound is the very finest *heat-resistant* phenolic available in its cost range.**

12985 retains high flex strength after severe heat aging. It has a rich, black color which it maintains well on exposure to heat. The material has a drop impact strength higher than its best competitor . . . equivalent *for the first time* to a general-purpose compound. 12985 takes a hot, speedy preheat and cures rapidly. It has excellent machining properties, good chemical resistance, relatively low specific gravity (1.58). And—it is offered at an attractive price.

SUGGESTED USES: This superb high-temperature material is particularly recommended for handles on skillets and cutlery, for appliance parts, switch and lamp parts, knobs, wiring devices, miniature parts for use at high ambient temperatures.

G-E 12941 **A new concept in general-purpose phenolics: a fast-curing, ammonia-free, non-bleeding black compound.**

This material gives an extremely fast, blister-free, cold-powder cure. There is no danger of staining the mold or tarnishing costly silver contacts. Nor is there any need to worry about high scrap losses caused by uneven flow. Parts produced from 12941 will not bleed.

SUGGESTED USES: Ideal for small, automatically molded parts of all kinds: switch parts, contacts for wire connectors, closures, tube sockets, appliance control parts.

G-E 12942 **This new variant of a popular general-purpose compound offers added impact strength, improved finish and cure.**

A versatile and easily molded compound, 12942 pre-forms well, takes a hot preheat, and flows smoothly in the mold. Parts made of the new compound are smooth, rigid, deep-black, and will not embrittle during tumble finishing. It can be used in cold powder automatic molding with just a slight penalty in cure speed. It is not hand staining.

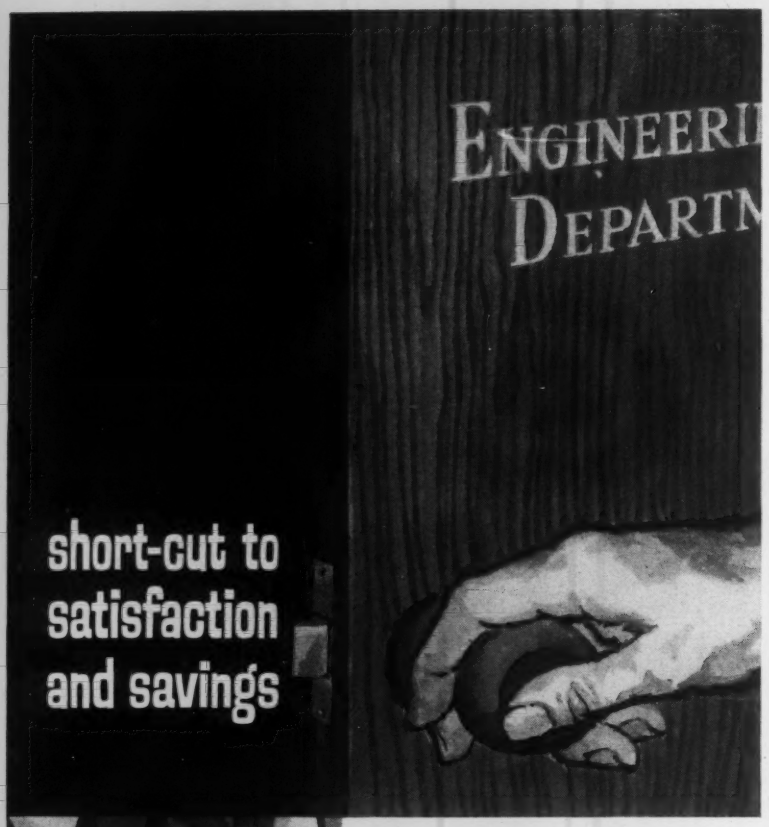
SUGGESTED USES: General applications such as handles, knobs, meter case covers, coffee maker bases, piano sharps.

These three new compounds may well give you an important advantage in processing or properties. General Electric offers you dozens of standardized phenolic compounds, including general purpose, heat resistant, shock resistant, and fast cure phenolics. Our Technical Service people will be glad to help you select the right material for your job. For more information, write to: General Electric Company, Section M-661, Chemical Materials Department, Pittsfield, Mass.

Phenolics-first of the modern plastics...first in value

GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 374



Rolled Steel Rings of simple or complex cross-section can be produced by the Edgewater process, in diameters from 5 to 145 inches. Materials include carbon steel, stainless and heat-resisting alloys, tool steel.

Edgewater's first step in answering an inquiry for rolled steel rings is to have Engineering check the proposed design for possible modifications that would improve the ring and/or reduce the price. This assures a good design—one that meets all requirements, at lowest cost.

Forged from solid blocks of steel and rolled on a powerful ring mill, Edgewater weldless rings are formed to cross-section shapes so close to finished dimensions that very little machining is needed. Close tolerances mean less labor, less scrap loss, lower overall costs. The Edgewater rolling process assures maximum strength, toughness and uniformity. Send drawings for recommendations and prices.

INTERESTING description of the ring-rolling process is given in this brochure, **Edgewater Rolled Steel Rings.** We will be glad to send you a copy.

Edgewater Steel Company

P.O. Box 478 • Pittsburgh 30, Penna.

For more information, turn to Reader Service card, circle No. 336

ing were oriented in a circumferential direction; the middle layer in a longitudinal direction. Specimens had a 1 1/2-in. i.d. and a cross section area of 0.625 sq in. A longitudinal/circumferential ratio (cross section areas) of 0.976 produced the best high temperature compression strength.

Laminates used for flexural strength tests were ⅛ in. thick. The flexural strength data shown in the graph were obtained using a span/depth ratio of 39:1.

Improved handling

Originally, wet winding with VC-8359 required that extensive precautionary measures be taken, complicating the process. Maleic anhydride, the curing agent used, is an irritant to mucous membranes and has a strong tear gas effect.

This difficulty has been virtually eliminated by reacting the resin and maleic anhydride to the B-stage in a toluene solution.

The 100% solid material and the B-staged solution are available at $4 per lb from Brunswick-Balke-Collender Co. The shelf life of these materials is in the neighborhood of two weeks at room temperature, and can be extended considerably by refrigeration. Prepregs claimed to have excellent drape and tack characteristics are also available.

Electrical Connections for High Temperatures

by W. P. McQuillan*

Several welding techniques and brazing alloys produced electrical connections with good endurance in recent tests at 930 F.

These are among the encouraging results of an application study conducted by Westinghouse Electric's Materials Laboratories. High temperature oxidation was one of the most difficult problems encountered. Connections were evaluated for tensile strength, current carrying ca-

*Materials Engineering Dept., Westinghouse Electric Corp. Information that will be useful in conjunction with these findings was presented in "Electrical Insulations for 930 F Plus" on p 100 of the October issue.

Here's why you should consider

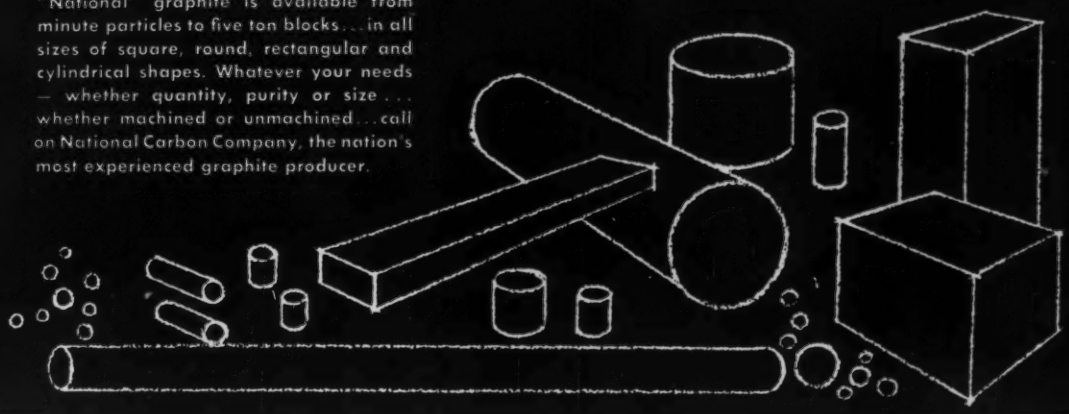
NATIONAL GRAPHITE
TRADE-MARK

...it has a unique combination of properties

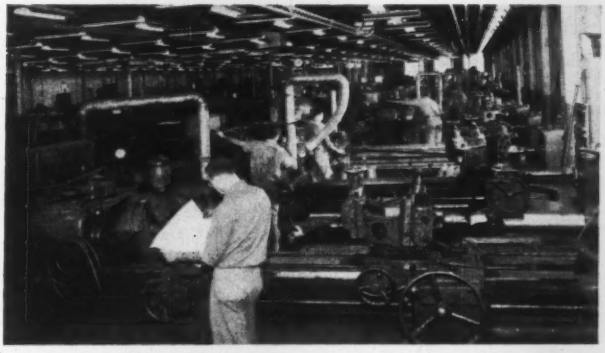
RESISTS THERMAL SHOCK	**GOOD ELECTRICAL CONDUCTIVITY**	**CORROSION RESISTANCE**	**STRENGTH INCREASES WITH TEMPERATURE RISE**
HIGH THERMAL CONDUCTIVITY	**LOW THERMAL EXPANSION**	**NOT WET BY MOST MOLTEN METALS**	**EASY TO FABRICATE**

...it's available in a wide variety of sizes and shapes

"National" graphite is available from minute particles to five ton blocks... in all sizes of square, round, rectangular and cylindrical shapes. Whatever your needs — whether quantity, purity or size... whether machined or unmachined... call on National Carbon Company, the nation's most experienced graphite producer.



...and NATIONAL CARBON can machine it to your specifications



One of several well equipped NATIONAL CARBON machine shops for fabricating graphite.

Economically machining graphite at National Carbon Company is a result of years of graphite machining experience teamed with modern equipment located at several strategic locations. Turning out simple or intricate shapes and holding to close tolerances are everyday procedures at these shops. No job is too small or too big, too simple or too complex to receive the required expert consideration and attention.

Whatever your needs, whether simple or complicated parts made from standard or special grades, let National Carbon Company quote on your requirements. For details, contact your National Carbon representative or the nearest sales office.

"National" and "Union Carbide" are registered trade-marks for products of

NATIONAL CARBON COMPANY
Division of Union Carbide Corporation • 270 Park Avenue, New York 17, New York
IN CANADA: Union Carbide Canada Limited, Toronto

UNION CARBIDE

For more information, turn to Reader Service card circle No. 473

ElastaCAST®

SOLVES CRITICAL MATERIAL SELECTION PROBLEMS

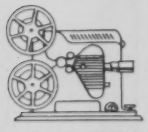
Automotive Ball Joint Seal. *"30,000 miles without ball joint lubrication" resulted from Ford Motor Company's use of oil-resistant ElastaCAST for ball joint seals in its 1961 Fords, Mercurys and Lincoln-Continentals. This application takes advantage of ElastaCAST's abrasion resistance, tear strength, excellent weathering properties and low permanent set.*

If you are planning a product that requires a material with unusual properties, take a look at ElastaCAST. Let us work closely with you, particularly in your early design work; experience has shown us that definite savings in design, production and the finished part generally result.

ElastaCAST is a new liquid polyurethane elastomer possessing an unusual range of mechanical and physical properties — such as outstanding abrasion, tear and ozone resistance, oil and gas resistance and high load-bearing. Here's a whole new sales advantage made possible through our rubber and plastics technology. Call us about your tough or unusual applications.

ACUSHNET PROCESS COMPANY
760 Belleville Avenue, New Bedford, Mass.

Acushnet



Light Drive Rolls *of ElastaCAST assure longer life... higher drive friction.*

Shoe Toplifts *of ElastaCAST outwear nylon, rubber or leather . . . take impact bearing loads up to 7,000 psi.*

Textile equipment bearings *of ElastaCAST outlast metal as well as conventional rubbers and plastics.*

Please send my copy of your new 16-page ElastaCAST Design Manual.

*Name*_____

*Title*_____

*Company*_____

*Address*_____

*City*_____ *Zone*_____ *State*_____

For more information, turn to Reader Service card, circle No. 427

pacity and high temperature electrical resistance after 100 hr at 930 F.

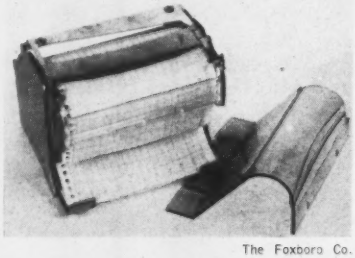
Welding was found to be better than brazing for high temperature joints. Brazing sometimes introduces a problem in removing flux, and may cause heat damage to the wire adjacent to the joint. The high melting point and superior oxidation resistance of welded joints also make them more acceptable.

Welded joints

Welded connections survived 100 hr at 930 F without serious impairment. Recommended welding techniques for pigtail joints made of three metals are:

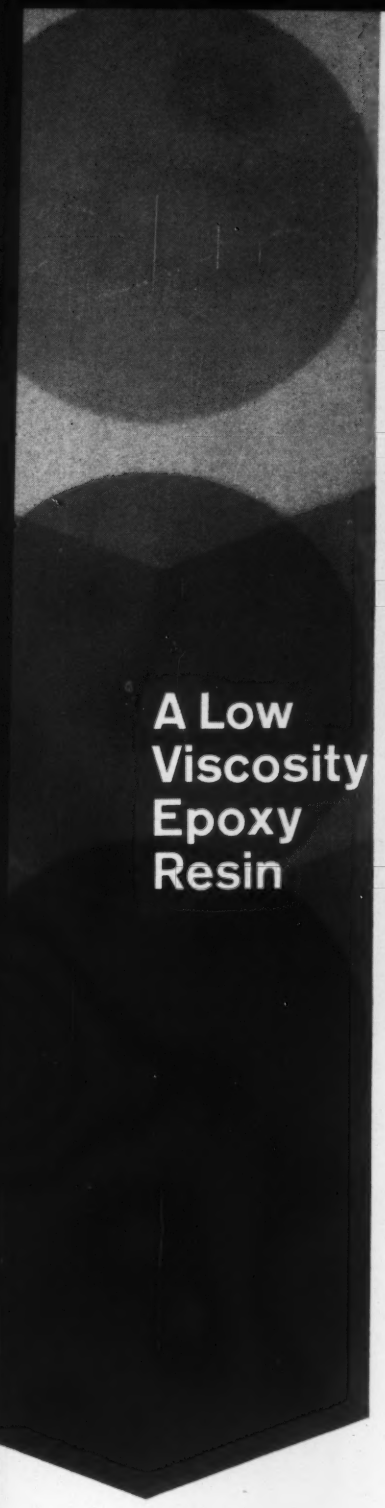
1. Aluminum: inert-gas-shielded arc.
2. Silver: inert-gas-shielded arc, or flame.
3. Nickel-coated copper: inert-gas-shielded arc. Using a nickel or silver filler when welding nickel-coated copper wire-to-wire connections insures maximum oxidation resistance. Applying these fillers does not appear to add significantly to electrical resistance.

continued on p 152



The Foxboro Co.

Heat resistance of Lexan polycarbonate plastic was the decisive factor in choosing it for the injection molded recorder guide shown above. This material withstands up to 270 F without distortion and therefore is not affected by heat from the recorder's internal lighting. Polycarbonate resin was the only material found to have all of the properties required for the part: transparency, high impact strength, heat resistance, and a smooth finish to prevent the recorder chart from snagging.



New... From CIBA Research

A Low Viscosity Epoxy Resin at lower cost

For Casting
Encapsulating
Potting
Impregnating
Tooling
Laminating
Flooring

Plus these advantages . . .
pleasant odor
less skin sensitizing
lower vapor pressure
higher flexural strengths

CIBA
First in Epoxies

CIBA Araldite 507

Specifications

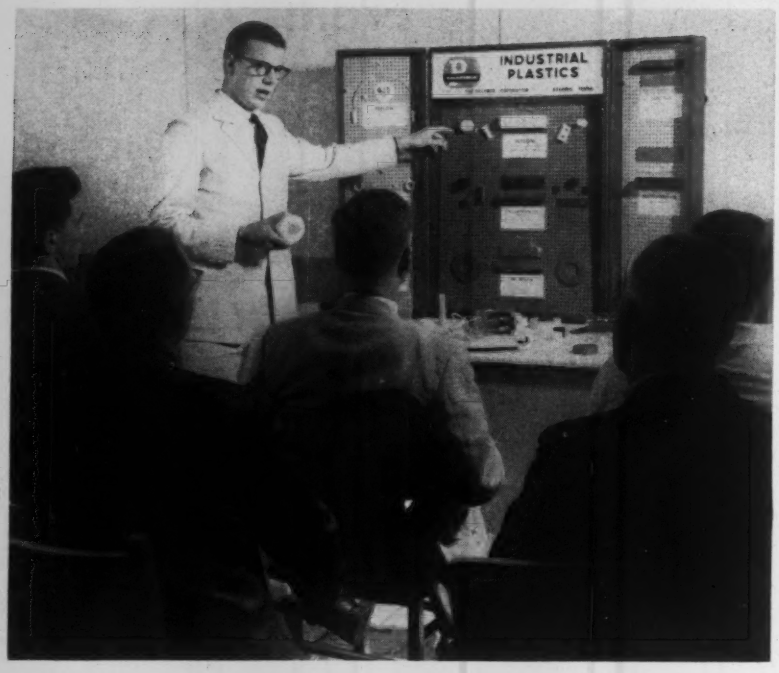
Viscosity, at 25°C., cps.	500—700
Epoxy Value, Eq./100 gm.	0.52—0.54
Weight per Epoxide (WPE)	185—192
Weight/Gal., lb.	9.4—9.6

Araldite® 507 is a new low-viscosity modified epoxy resin. The modification, accomplished during manufacture, results in a liquid (epichlorohydrin-bisphenol A) epoxy resin in combination with a proprietary monoepoxide reactive diluent.
For further information on Araldite 507 write:

CIBA Products Corporation
Fair Lawn, New Jersey

For more information, circle No. 488

C I B A



Quick way to get up-to-date on the use of new plastics

Call your nearby Polymer representative for a "*Parade of Plastics*" presentation of the newest and most important POLYPENCO® industrial plastics applications. See for yourself how progressive industries are now putting plastics to work cutting material costs, improving performance and extending the life of parts in all types of machinery and equipment.

You'll get valuable tips on new design possibilities as well as time and money-saving ideas for new maintenance and tooling improvements. *Polymer* "*Parade of Plastics*" will bring you up-to-date on new availabilities . . . new and different applications that may be the answer to your immediate problem or the long-range solution to others in your plant.

"It pays to keep posted on plastics, and *Polymer* '*Parade of Plastics*' is the fast, easy way to do it . . . without obligation, of course."

Write for Bulletin BR-1, your plastics story in print, or contact your Polymer representative for further information.

POLYPENCO®

THE POLYMER CORPORATION OF PENNA.

Reading, Pa. / Export: Polypenco, Inc., Reading, Pa., U.S.A.

Plastics Engineering in Action

NYLONS • TFE-FLUOROCARBONS • OTHER PREMIUM PLASTICS

For more information, turn to Reader Service card, circle No. 367

Inert-gas-shielded arc welding of nickel-coated copper wire to type 347 stainless steel or nickel terminals with a nickel or silver filler produced the best wire-to-terminal connection. Silver wire to silver terminal joints, arc welded without a filter, were also satisfactory.

Brazed joints

Oxidation resistance was the most critical property in the evaluation of brazing alloys intended for high temperature service. Some alloy compositions were found to be satisfactory for brazing joints where welding is not feasible. Special configurations were used to minimize stresses in these joints.

Protecting brazed joints from oxidation by means of electroplating and coating was also studied. Electroplating with nickel or silver produced the best results. This approach to the problem of oxidation is limited to applications where joints are accessible enough for electroplating.

Delicate Friction Job Handled by Acetal Resin

Two unusual properties of acetal resin have made possible the design of an accurate memory device for torque wrenches (see Fig 1 on p 154). The significant properties are the resin's dimensional stability and its static coefficient of friction which is virtually equal to its dynamic coefficient.

The memory devices, shaped like clothespins in Fig 2 and 3, travel across the scale with the main torque wrench pointer; when torque is removed and the main pointer returns to zero, the memory device remains on the scale to indicate the maximum torque that has been exerted.

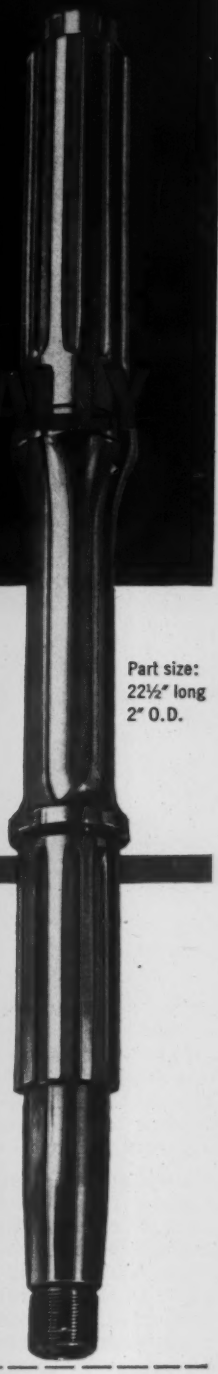
Constant friction required

For accurate readings, the static coefficient of friction of the device must nearly equal the dynamic coefficient; this is to prevent the cleft end from intermittently sticking and slipping as it rides in its track. The device exerts a cantilever spring force on the track surface, as shown in Fig 3. The part must also be dimen-

Rockwell-Standard Corp.
Transmission and Axle Div., Oshkosh, Wis.
changes from hot-rolled A-4140 to

fatigue-proof
STEEL BARS
elevated temperature drawing process **e.t.d.**

INCREASES PRODUCTION SUBSTANTIALLY — doubles tool life



Part size:
22½" long
2" O.D.

Increases turning production 20%

Increases drill life 50%

Eliminates heat treating

Here's an example of how a small additional investment in material enabled Rockwell-Standard to increase production and cut cost on an axle for farm equipment.

Part: Transmission shaft for a self-propelled harvester.

Steel: FATIGUE-PROOF steel bars . . . replacing HR resulphurized A-4140.

Result: Heat treating eliminated. More uniform hardness across the section (302 Brinell) including small diameters. Hand straightening eliminated. Shaft runout in turning, reduced from an average of .015" to .005" in turning. Lower cost per part.

PRODUCTION INCREASES

Turning Operations: Speed increased approximately 45%. Tool life increased from 12 to 25 pieces per tip . . . tungsten carbide tips were used.

Drilling Operations: Drill life increased approximately 50% with FATIGUE-PROOF.

Milling Keyway: Entire lot of 550 pieces were run on one cutter . . . cutter formerly required sharpening after 300 pieces.

Hobbing Operations: Production increased approximately 60% . . . from 26 pieces per hour to 44.2 pieces. Hob life doubled.

FATIGUE-PROOF* steel bars offer all these cost cutting advantages.

No heat treating necessary—no quench cracks, warpage or other heat treating problems. Costly operations eliminated.

Exceptional Uniformity—from surface to center, end to end, bar to bar, size to size, and lot to lot.

Faster Machining—faster than annealed alloys; 50% to 100% faster than heat treated alloys.

La Salle STEEL CO.

1418 150th Street
Hammond, Indiana

* Available from your Steel Service Center

Send for FATIGUE-PROOF bulletin entitled, "A New Material." 24 Pages. Do it today!

NAME_____
TITLE_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE____ STATE_____

For more information, turn to Reader Service card, circle No. 482

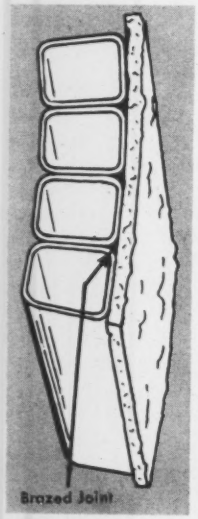
HOW TO MAKE A SPAGHETTI BUNDLE

to cool a rocket engine

In the newer liquid fuel rocket engines, cooling of the thrust chamber's inner shell is accomplished by means of spaghetti bundles of stainless steel tubing. Fuel flows through the tubing at −35°F. At the same time, its outer wall is subject to a temperature of 1350°F. Pressure differentials up to 400 psi occur.

Fabrication involves joining thin pieces of tubing lengthwise. Welding is impractical because of distortion and penetration. Brazing solves the problem, but requires a special alloy —one that is highly ductile—that assures leak-tight joints and retains its strength at elevated temperatures. Coast Alloy No. 62 meets these requirements perfectly.

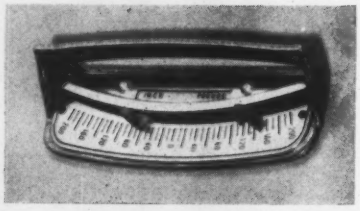
Development of alloys for specific purposes is a field in which Coast Metals has led the way for twenty five years.


Brazed Joint

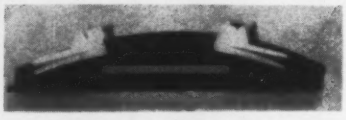
A Coast Metals Alloy may solve one of your brazing problems. Write

Coast Metals, Inc., Little Ferry, N.J.
ALLOYS for HARD FACING and BRAZING • CASTINGS

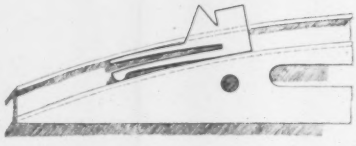
For more information, turn to Reader Service card, circle No. 366



1 Memory device *preserves maximum torque indication after torque on the wrench is relaxed.*



2 Acetal resin *device rides in curved track.*



3 Cleft end *of memory device maintains continuous low friction force.*

sionally stable to maintain the friction force on the track constant throughout the life of the tool, under varying temperature conditions.

Du Pont's Delrin acetal resin is the only material that has the properties needed for this application, according to P. A. Sturtevant Co. of Addison, Ill., manufacturer of the wrenches and the injection molded pointers.

The resin has static and dynamic friction coefficients that are practically equal. It has excellent dimensional stability with varying temperatures, even up to 212 F, and is said to show almost no cold flow over several years of time. The cold flow experienced by the material is so slight that the resultant loss of friction force is counteracted satisfactorily by the dust that normally accumulates on the tool during usage.

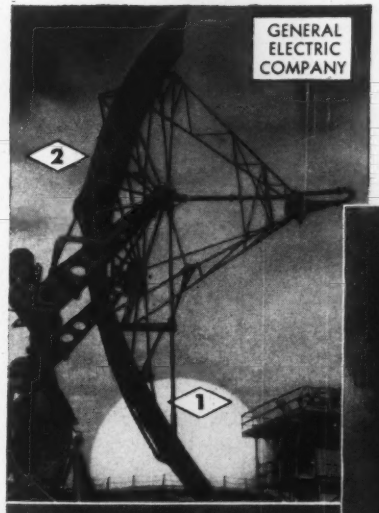
The drag of the memory device is said to affect average torque wrench accuracy no more than 1/37 of 1%. The memory feature has been in-

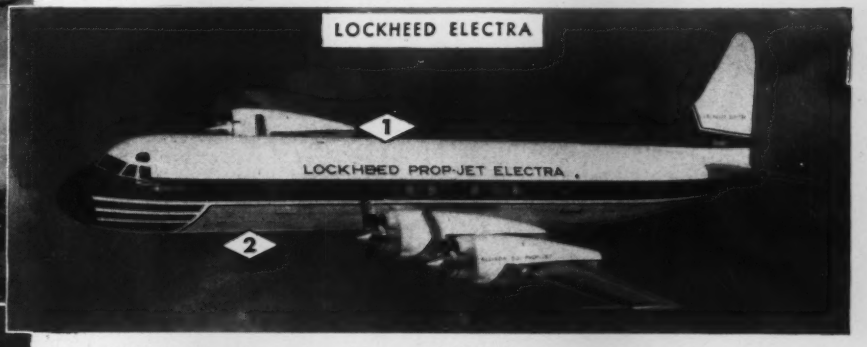
LOOK FOR THE DIAMONDS—SIGN OF FINISHING QUALITY

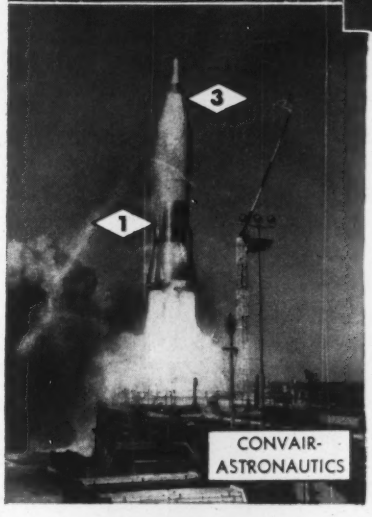
for a superior paint base on light metals you need IRIDITE®

PROCESS ENGINEERED CHROMATE CONVERSION COATINGS

1. Iridite protects against high altitude weather extremes and against corrosion by hydrocarbon fuels, such as gasoline and kerosene.
2. Iridite provides a highly protective non-porous paint base.
3. Iridite protects against corrosive storage conditions.







And, Iridite gives you these additional advantages:

ON ALUMINUM—needs only normal pre-cleaning. Film withstands cold forming or bending. Easily heliarc welded. Unusually low electrical resistance. Clear, yellow or dye-colored finishees.

ON MAGNESIUM—short immersion, room temperature solution, no electrical equipment. Corrosion protection relatively unaffected by high drying temperatures. Applicable to all alloys. Low electrical resistance. Color ranges from light gray to dark brown.

IRIDITE—a specialized line of chromate conversion coatings for non-ferrous metals. Easily applied at room temperatures with short immersion, manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel; special equipment, exhaust systems or highly trained personnel not required.

Iridite is approved under government and industrial specifications.

For complete information on Iridite, contact your Allied Field Engineer. He's listed under "Plating Supplies" in the yellow pages. Or, write for FREE TECHNICAL DATA FILES.

Allied Research Products, Inc.

4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND

Affiliated operations in principal countries

For more information, turn to Reader Service card, circle No. 436

FRONTIER
40-E NEWSCAST

40-E® Aluminum Alloy Improved

YIELD, TENSILE STRENGTH, ELONGATION INCREASED

■ Changes recently made in the metallurgical formula for Frontier 40-E Aluminum Alloy have further improved its excellent mechanical characteristics. Specification minimums for this high strength casting alloy are:

Yield Strength	25,000 psi
Tensile Strength	34,000 psi
Elongation	4%

(NOTE: *Specification minimums are not to be confused with accepted "typicals" which are usually higher.)*

This is the latest in a series of improvements made by Frontier Bronze since it introduced 40-E more than 20 years ago. It gives the designer even greater values for applications requiring light weight and high strength.

OTHER DESIRED PROPERTIES RETAINED

To assure maintenance of 40-E's many desirable qualities, extensive tests are carried out before any formula changes are standardized. Some of these well-known properties are:

Shock Resistance — exceptional ability to withstand explosive and impact shock.

Corrosion Resistance—excellent resistance to salt water corrosion and stress corrosion. Polished parts retain their finish.

Pressure Tightness — fine grain structure withstands high pressures without impregnation.

Machineability — superior to usual sand cast aluminum alloys. Machined parts have a high lustre.

NO HEAT TREATMENT NEEDED

Frontier 40-E stabilizes at high strength with good ductility through a short period of natural aging at normal room temperature. This eliminates special and costly solution heat treatment and straightening troubles. Consequently, natural re-aging after welding or brazing brings back the same high strength and toughness throughout the casting.

NO SUBSTITUTE FOR 40-E

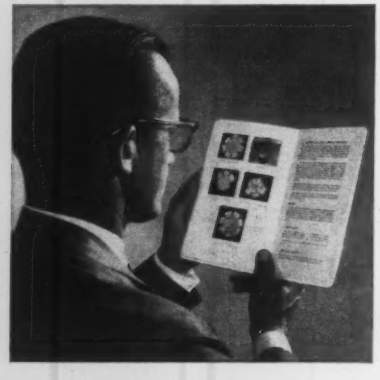
It is necessary always to specify Frontier 40-E Aluminum Alloy if the properties described above are desired consistently. All primary metal plus tight laboratory controls and careful melt procedures assure the uniform quality of Frontier 40-E, ingot after ingot. And these are backed by a certified analysis of material furnished with every shipment.

FRONTIER FOLLOW-THROUGH

Frontier service continues after the sale. Customers *must* be satisfied with the results they achieve through use of Frontier 40-E. To that end, analytical, testing and foundry practice services are freely offered to assist you in obtaining top quality results.

FREE DATA BOOK

A 24-page handbook detailing the properties and uses of Frontier 40-E Aluminum Alloy is free for the asking. Write for it today.



FRONTIER BRONZE CORPORATION
4876 Packard Road
Niagara Falls, New York

For more information, turn to Reader Service card, circle No. 334

corporated into torque wrenches, spring-rate testers and torque testing fixtures sized from 0-32 in.-oz to 0-200 ft-lb.

This memory device was designed by Thomas Green, P. A. Sturtevant Co., and entered in the most recent M/DE Awards Competition.

Magnesium Improves Galvanized Steel

The corrosion resistance of galvanized steel is increased 20 to 90% by adding a slight amount of magnesium to the coating, according to Dow Chemical Co. This appraisal follows a six-year test program in an industrial-marine environment.

The concentration of magnesium that provided maximum protection was between 0.04 and 0.05%. The increase in cost of galvanized steel resulting from such an addition is expected to be slight in comparison with the increase in corrosion resistance offered.

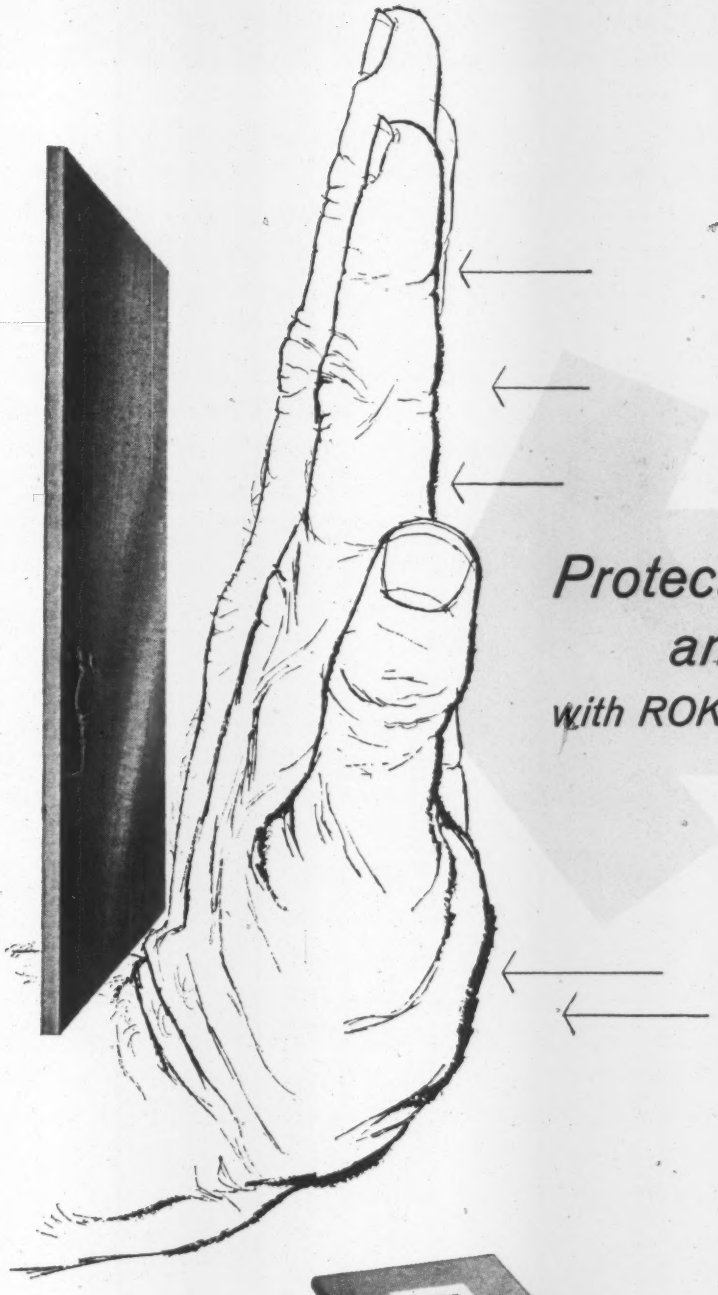
TFE Lining Speeds Molasses-Feed Flow

Lining an automatic molasses-feed scale with TFE sheet prevents the molasses from sticking to the scale walls and clogging the scale. The lining is estimated to have saved $6700 annually, and to have improved production efficiency and scale reliability.

Previously, the extremely sticky molasses-feed mixture built up in the scale and clogged it, requiring the operation to be shut down while the blockage was removed. In addition, the scale had to be cleaned at least twice a day to remove deposits that built up in the weighing hopper and registered on the scale but were not delivered to the bags.

Beacon Milling Co. estimates that use of Teflon liners in one of its scales speeded production 7.5%, cut cleaning time 90% and maintained scale accuracy. The scale has not clogged once in four years of continuous use.

Teflon was selected for the liners after extensive investigations by



Here's the fast, economical way to protect vital parts and equipment against temperatures up to 4600°F . . . extreme abrasion . . . electrical energy . . . erosion and corrosion. Apply ROKIDE Ceramic Coatings — hard, crystalline refractory materials which provide *effective* protection.

ROKIDE Coatings are supplied in rod form as "Z" Zirconium Oxide, "A" Aluminum Oxide, "C" Chrome Oxide, "ZS" Zirconium Silicate, and "MA" Magnesium Aluminate. To apply, rod is heated and the molten particles projected at high velocity against the prepared surface, where they adhere and solidify.

ROKIDE Coatings are used for both military and industrial applications such as: missile components, bearing surfaces, extrusion dies, furnace and feed rolls, induction coils, igniter tips, strain gages, buffing fixtures, mechanical seal rings, pump shafts, capstan wheels, impellers, crucibles, etc.

ROKIDE Coatings are available from a number of strategically located job shop applicators or direct from Norton Company, Worcester, Mass., and Santa Clara, California. Find out how they can cut *your* maintenance and production costs. NORTON COMPANY, 350 New Bond Street, Worcester 6, Massachusetts.

Protect modern metals and materials

with ROKIDE Ceramic Coatings*

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries.

Write for full details on the ROKIDE Coating Process.

NORTON

REFRACTORIES

Crystallizing ideas into products

75 years of . . . Making better products . . . to make your products better

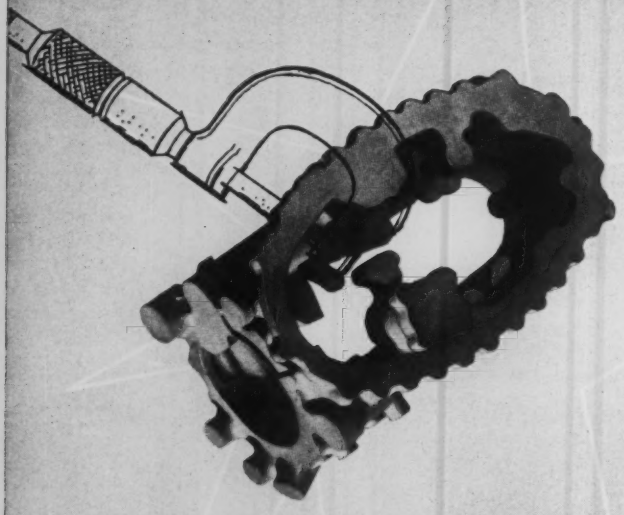
NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

For more information, turn to Reader Service card, circle No. 415

• tolerances
• soundness
• intricacy

"Believed Impossible"

WAUKE-SHA CASTINGS



Before now . . . it was thought impossible to cast alloys to dimensional tolerances of ±.005, without expensive machining.

Exclusive Wauke-Sha ceramic molds prevent voids, even with light and heavy adjacent sections, reproduce hairline intricacies without porosity or surface blemish. Only this patented Wauke-Sha process assures:

- intricate parts with no costly machining
- hairline reproduction of detail
- no cracking or tearing
- no porosity, internal voids, cracks
- no surface gas holes, blemishes, inclusions

Wauke-Sha castings make possible full design flexibility without limitation on casting size. Every day . . . Wauke-Sha castings are meeting the severe conditions in the nuclear field, where "soundness" is imperative.

Waukesha Foundry Company

WAUKESHA FOUNDRY CO.
Dept. F 22, Waukesha, Wis.
Manufacturers of corrosion-resistant castings, inclusive of non-galling alloys, Stainless Steel, Waukesha Metal, Monel, Pure Nickel, Inconel, Ni-Resist, plus special Nickel-Chromium Alloys for specific applications.

For more information, turn to Reader Service card, circle No. 399

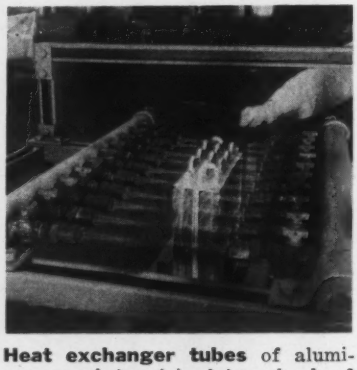
Richardson Scale Co., manufacturer of the scales, who found that stainless steel liners and streamlined design did not wholly solve the problem. The TFE sheets were supplied by Raybestos-Manhattan, Inc.

Hot Properties of W-Cb-Ta Alloys Studied

Ternary alloys of tungsten, columbium and tantalum have ten times the high temperature oxidation resistance of these metals in the pure state. And the hot hardness of these alloys is two to three times that of tungsten.

These are the major findings to emerge from a study of the W-Cb-Ta system by Union Carbide Metals Co. which foresees the possibility of a new high temperature structural material.

Alloy compositions covering the ternary system were tested for oxidation resistance by exposing them to flowing oxygen for 4 hr at 2190 F. Preliminary findings suggest that oxides of the alloy elements, forming a protective coating, may be the main



Heat exchanger tubes of aluminum are being joined in a bank of four rows by zinc soldering, as recently demonstrated by Aluminum Co. of America and Selas Corp. of America. Overheating, which has been an obstacle to joining more than two rows of tubes, is said to be avoided by the proper placement and adjustment of gas jets.

Now, make your urea moldings come alive with an unmatched surface brilliance—without sacrificing quality or economy. Three new high gloss formulations make this possible: Beetle 650, designed for small parts such as closures and buttons; Beetle 625, for closures, switch plates, wiring devices and small housings; Beetle 600, for large housings and other parts requiring extended flow. These new Beetle molding compounds cure faster, and they offer improved preforming qualities. And you still have all of these dependable Beetle properties: resistance to detergents, oils and grease; arc-resistance; track resistance; good dielectric strength; surface hardness; stain-resistance; wear-resistance; unlimited range of colors. Be among the first to take advantage of this bright new development. Write for complete information today. *BEETLE — registered trademark for Cyanamid's urea-formaldehyde molding compound.

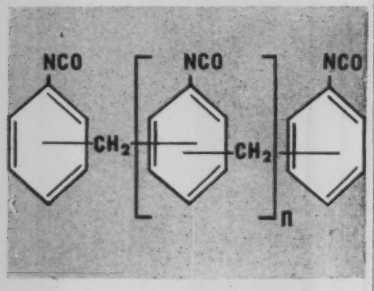
AMERICAN CYANAMID COMPANY CYANAMID PLASTICS AND RESINS DIVISION

WALLINGFORD, CONNECTICUT. *OFFICES IN:* BOSTON • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DETROIT • LOS ANGELES MINNEAPOLIS • NEW YORK • OAKLAND • PHILADELPHIA • ST. LOUIS • SEATTLE • *IN CANADA:* CYANAMID OF CANADA LIMITED, MONTREAL • TORONTO

For more information, turn to Reader Service card, circle No. 445

papi®

(Polymethylene polyphenylisocyanate)



ONE SHOT RIGID FOAMS
High strength at ultra low density PAPI polyether fluorocarbon based foams for refrigerator insulation.

HOT STRENGTH
PAPI based rigid polyester foams **retain** their strength after prolonged exposure to temperatures above the useful range of conventional urethanes.

EXCELLENT ADHESION
PAPI provides **excellent adhesion** between butyl, nitrile, haloprene, and other rubbers and a variety of substrates like polyester fiber, nylon, metal.

SAFER
PAPI is a nonvolatile reactive isocyanate that is easily used even for spray-in-place foams.

THE CARWIN COMPANY
NORTH HAVEN, CONN.

® T.M. Reg. U.S. Pat. Off.

Please send more data on PAPI.
Name_____
Company_____
Address_____
City_____ State_____

For more information, circle No. 378

cause of the oxidation resistance improvements.

Hardness tests were run at 2300 to 2900 F. Tensile strength testing has not been completed; however, judging from available data, it seems that high temperature values of tensile strength and hardness can be correlated.

Many of the high strength compositions are likely to have undesirably low ductile-to-brittle transition temperatures. An adequate evaluation of the alloy system for high temperature structural use requires further testing for this property and for tensile strength and fabricability.

Based on a study by J. L. Wilson and C. R. McKinsey, Metals Research Laboratories, Union Carbide Metals Co.

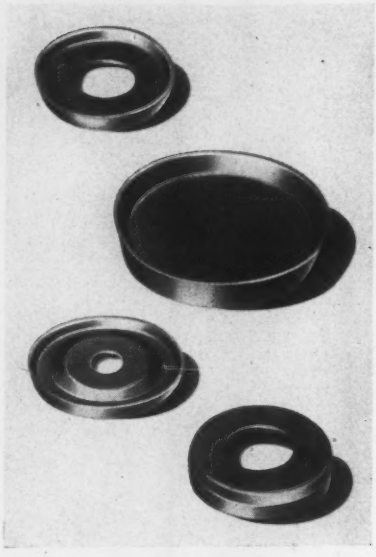
Polyester-Glass Spray Coat Fights Corrosion

The process of spray coating with glass-reinforced polyester for chemical corrosion resistance offers savings in cost and job time. This was evident in a recent application of a bisphenol-A polyester resin (Atlac 382, produced by Atlas Chemical Industries, Inc.) to protect steel tanks against damage from chlorine dioxide spillage.

Ease of application is the main advantage of the spray technique. On the job cited above, resin, promoter and chopped glass fiber were applied to the sandblasted tank surfaces in one spray gun operation. A homogeneous coating with good surface adherence was applied, according to the users, in about half the time that wet lay-up or ceramic tile would have taken.

This method is especially advantageous for covering irregular or inaccessible surfaces where other types of coatings would be extremely difficult to apply. In general, total job cost with this technique is said to be approximately 50% less than that of a comparable corrosion protection job using ceramic tile.

The coating described above is expected to last for at least ten years, according to an extrapolation of test data from the Chemical Fire & Rust Proofing Corp. of Great Neck, N. Y., which did this coating job.



RULON — first practical fluorocarbon for cup packings

Dixon's new post-forming technique makes use of Rulon's plastic memory to insure tight seals under all conditions . . . at lower cost than ever before!

Packings of Rulon (filled TFE) give you: (1) low friction, (2) high resistance to wear, (3) low deformation under load (½ that of Teflon*), (4) wide temperature tolerance (−400° to +500°F), (5) chemical inertness, (6) lube free operation, and (7) zero water absorption.

Dixon offers **RULON** and **TEFLON** in

- rods
- tubing
- sleeving
- sheet
- tape
- extruded shapes
- bearings
- bushings
- washers
- gaskets and packings
- bearing retainers
- machined and molded parts

RULON now serves in pumps, valves, motors, compressors and scores of other products manufactured by leading companies across the nation. Dixon offers the widest variety of basic shapes, both in RULON and Teflon . . . plus engineering capability to formulate special reinforced fluorocarbons for special needs. Also, Dixon can supply molded, machined, stamped, cut or extruded parts to meet your print.

See our guide-book on RULON, Bulletin #9572, in Sweet's Product Design File or send details for recommendations. DIXON CORPORATION, 102 BURNSIDE ST., BRISTOL, R. I.

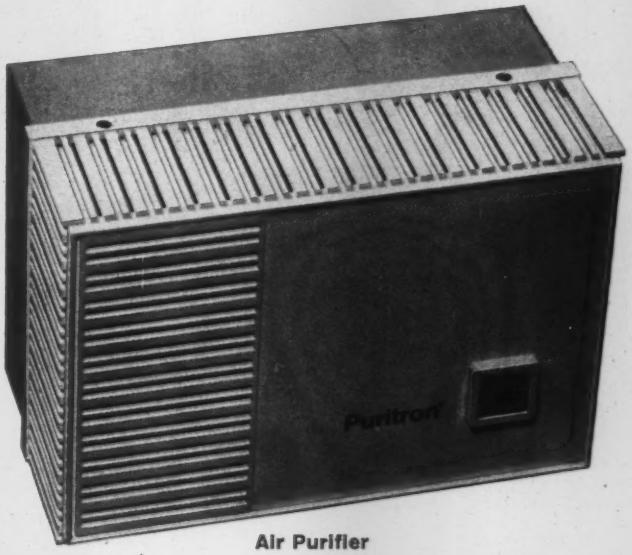
* DuPont T.M.

DIXON

For more information, circle No. 361

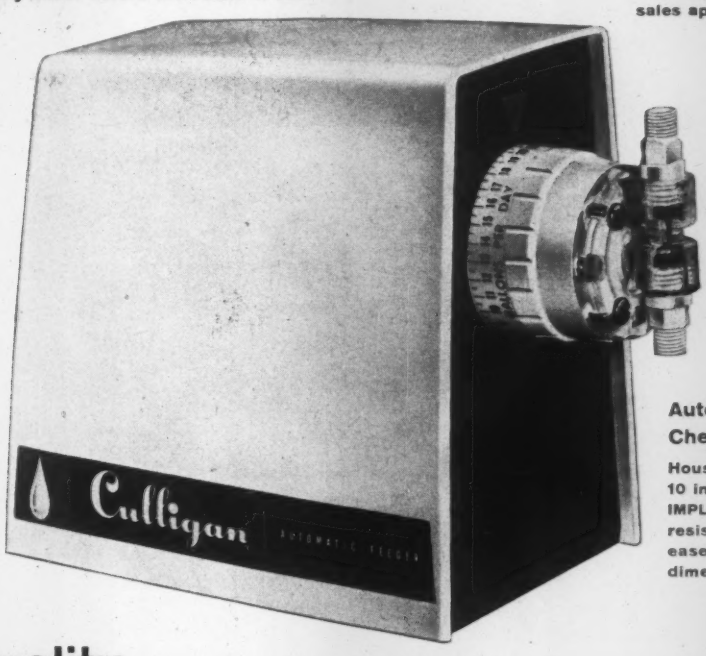
Trading Stamp Dispenser

Housing molded of IMPLEX for impact resistance, high gloss, durability under severe conditions of use.



Air Purifier

Housing molded of IMPLEX for excellent appearance, toughness, color stability, sales appeal.



Automatic Chemical Feeder

Housing, adjustment dial and 10 internal parts molded of IMPLEX for strength, stain resistance, surface hardness, ease of cleaning, dimensional stability.

High quality housings at moderate cost

Housings that match quality appearance with quality performance are just some of the host of parts in many fields that are now being molded of IMPLEX® acrylic plastic. You'll find the specific combination of properties *you* need in one of the five formulations of IMPLEX. Write today for full information on *tough . . . colorful . . . stain-resistant* IMPLEX.

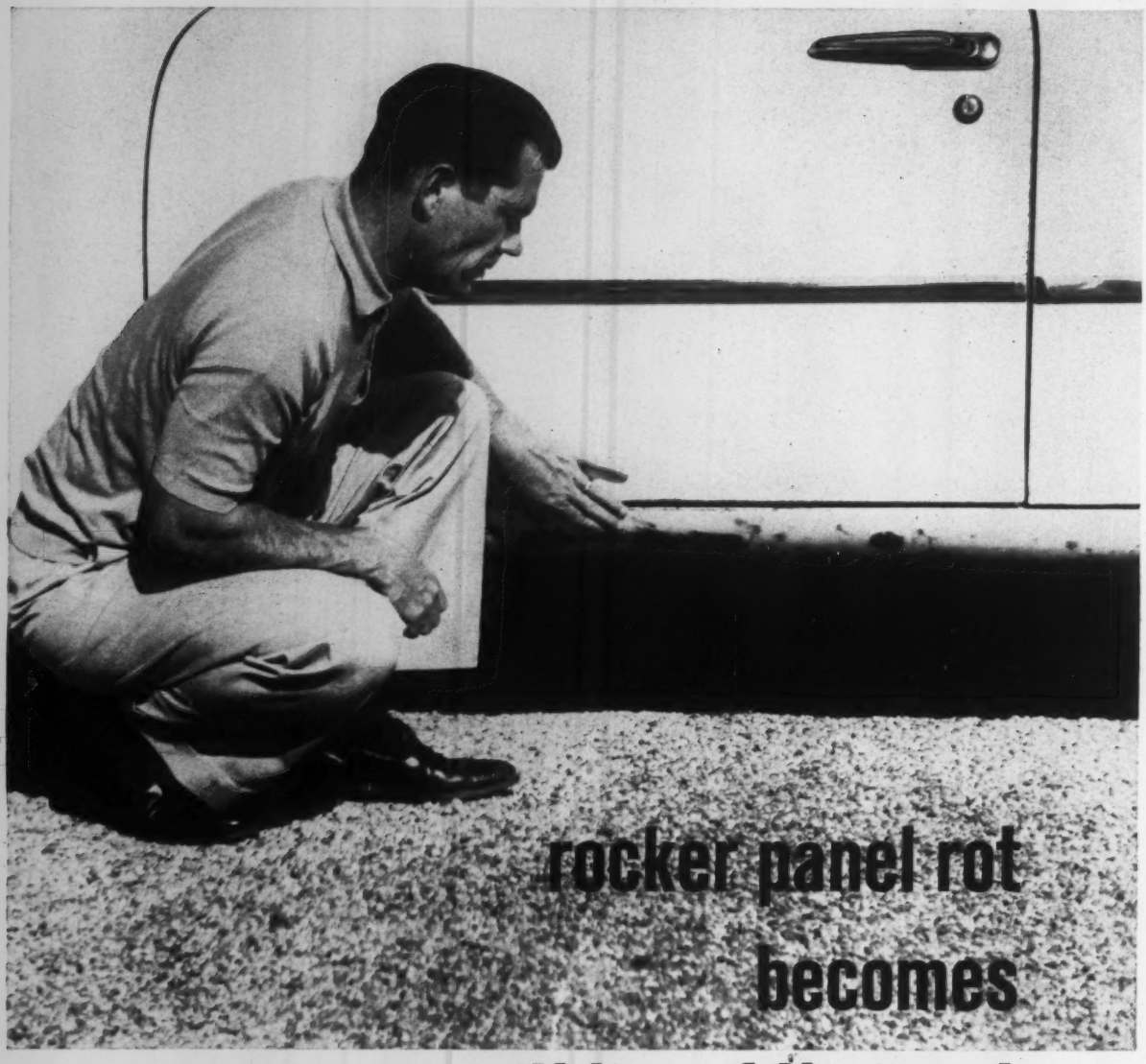
ROHM & HAAS

PHILADELPHIA 5, PA.

In Canada: *Rohm & Haas Company of Canada, Ltd., West Hill, Ontario*

IMPLEX

For more information, turn to Reader Service card, circle No. 344



a thing of the past

Rocker panels have been rusting from the inside out years ahead of other parts of the body. One obvious answer was to form them from corrosion resisting hot dip galvanized. Except that paint peels off galvanized in no time unless it's properly treated. The crying need was for a single phosphating solution to treat steel and hot dip galvanized effectively and at the same time.

Parker's got it!

Bonderite 37, now in use in many automobile body lines and appliance plants, makes paint stick to galvanized like a brother, and creates a corrosion resisting paint bond on steel that matches the high performance of Bonderites that are formulated for steel alone.

If you want to use painted hot dip galvanized for a component that is corrosion-prone, Bonderite 37 is probably your answer, too. Get full information. Write Parker today.

Parker Rust Proof Company,. 2173 E. Milwaukee, Detroit 11, Michigan.

PARKER

FIRST IN SURFACE TREATMENTS FOR METALS SINCE 1914

Bonderite

*Reg. U.S. Pat. Off.

For more information, turn to Reader Service card, circle No. 491

(Refractory metal cloth— cont'd from p 15)

What's new IN MATERIALS

cold or hot rolling or calendering. Rolling pressures for tantalum cloth were as high as 500,000 psi. Cloth thickness was reduced about 40% while conductance or pumping speed for nitrogen at room temperature was reduced from 280 to 0.1 ml/sec/sq cm. The lower value is comparable to that of sintered porous tungsten about ⅛ in. thick.

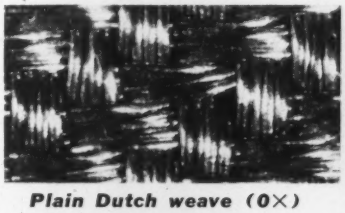
Pore geometry is complex but uniform. Also, permeability can be predicted and controlled to within 5%, as compared with ±50% variation for porous sintered compacts.

Other uses possible

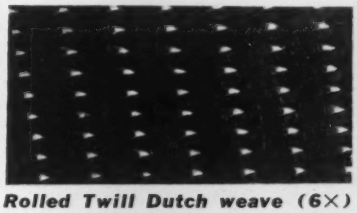
Although the cloth weaving technique was developed for ion emitters, other applications appear promising. Refractory metal cloth could replace many sintered porous structures where strength, flexibility and large sizes are necessary.

Such cloths could be used for directly heated dispenser cathodes or large electron emitters, for film-cooled rocket nozzles, and for arc electrodes. Other possible uses: filters for high temperature fluids and liquid metals; flame holders; and catalysts. KEY NO. 611

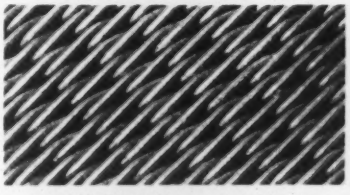
Some Tantalum Wire Configurations . . .



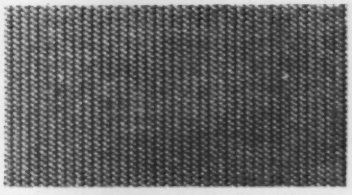
Plain Dutch weave (0×)



Rolled Twill Dutch weave (6×)



Twill Dutch weave (6×)



Finest Twill Dutch weave (17×)

325 × 2300 mesh

Powerful Superconductive Magnet

What is described as the most powerful magnet ever built for its size, weight and energy consumption has been announced by Westinghouse Electric Corp., Box 2278, Pittsburgh 30, Pa.

The new magnet is wound from a very fine wire made of a columbium-zirconium alloy that loses all of its electrical resistance at temperatures near –459 F. Once started, currents of electricity flow through the material forever without loss in strength. Special processing techniques (un-

You can depend on

Tempilstik°

temperature indicating crayons

Each batch of Tempilstiks° is certified for melting point by our laboratory — and independently tested for accuracy by a distinguished firm of metallurgical chemists.

A PRODUCT OF AMERICAN INGENUITY

Tempilstiks° have earned an enviable acceptance as one of the standard methods of determining temperatures—in both science and industry. This gratifying position is the result of many years of accumulated know-how and unremitting research and development.

Available in 100 systematically spaced temperature ratings—from 100° to 2500° F.....$2.00 each.

Most leading industrial supply houses carry Tempilstiks°. If yours is an exception, write to:

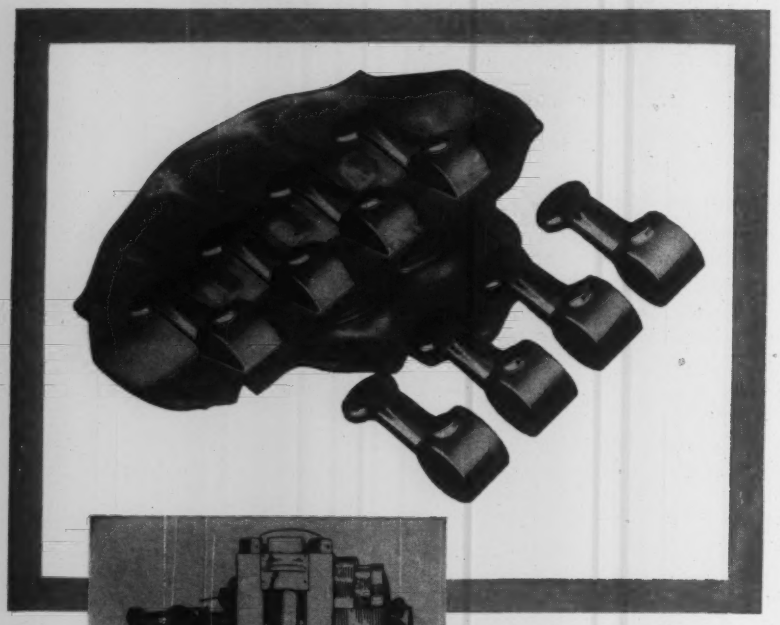
INDUSTRIAL DIVISION

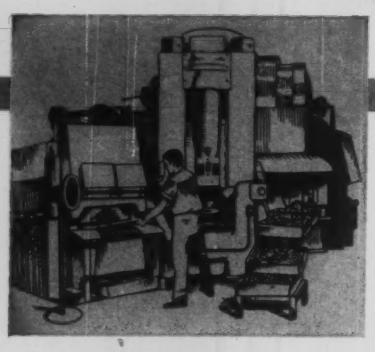
Tempil° CORPORATION

132 West 22nd St., New York 11, N. Y.

For more information circle No. 380

LOOK what brass is doing now!





Here's low cost for you!

This is 4-in-1 production of a Titan brass forging with high strength and consistent metal soundness. Close tolerances are maintained. There is less scrap waste. Costs are reduced.

And then you have the unparalleled machinability and natural finish of these brass forgings to take the finest polish or plating.

Like economies and advantages can be yours when you switch to Titan hot-pressed brass forgings. Let us help design and quote on *your* component parts.

Call your nearest Titan Man for detailed data and a brass forging quote. Titan forgings are made in Bellefonte, Pa., and Newark, Calif., for quick service and delivery.

Send for 32-page Titan Forging Handbook. Write us on your letterhead.

TITAN METAL MANUFACTURING COMPANY

DIVISION OF CERRO CORPORATION

Established 1915

Bellefonte, Pa. • Newark, Calif. • Offices & Agencies in Principal Cities
RODS • FORGINGS • DIE CASTINGS • WELDING RODS • WIRE

For more information, turn to Reader Service card, circle No. 370

What's new IN MATERIALS

disclosed) are used to prepare the brittle wire.

Magnet is small

The new magnet is the size of a doughtnut and weighs 1 lb. It creates a magnetic field twice as strong as that from a conventional iron-core electromagnet weighing 10 tons and operated to saturation of the iron.

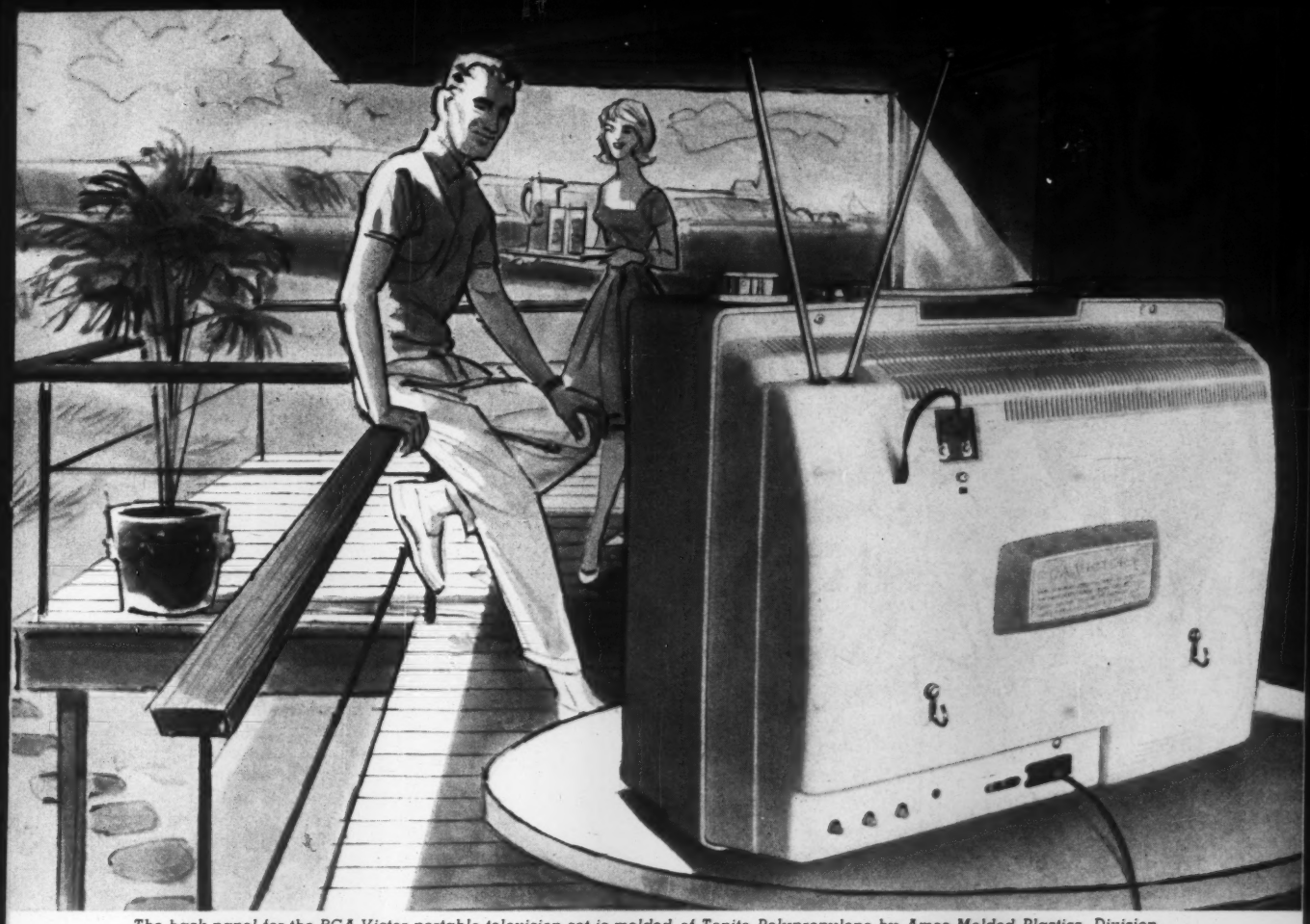
Westinghouse's superconducting magnet contains a half mile of the columbium-zirconium alloy wire. About 5000 turns of the wire are wound into a coil measuring 2 in. in dia and 1½ in. long. The coil is immersed in liquid helium to keep it at a temperature near —450 F. The company says energy required to cool the coil is only a small fraction of that needed to create a comparable magnetic field with a standard electromagnet.

The superconducting magnet produces a magnetic strength of 43,000 gausses. It has no iron core. Iron-core magnets begin to saturate at about 20,000 gausses, and can be driven to greater strengths only by applying large amounts of power that force the magnets beyond saturation; their coils would melt almost instantly if they were not oil or water cooled.

Atom smashers, space ships

According to Dr. J. K. Hulm, associate director of the Westinghouse research laboratories, a superconducting magnet "enhances consider-

Coil of wire *here is said to be most powerful magnet ever built.*



The back panel for the RCA Victor portable television set is molded of Tenite Polypropylene by Amos Molded Plastics, Division of Amos-Thompson Corp., Edinburg, Indiana.

A great show by a plastic—
TENITE POLYPROPYLENE

Long-run performance and a handsome appearance—two design essentials—are featured in the back panel of the RCA Victor portable TV set. The material that made them possible is Tenite Polypropylene.

Tough, durable Tenite Polypropylene takes the knocks and jolts, protecting the delicate internal components of the set. It withstands elevated temperatures—articles made from it can even be sterilized. Yet the flow properties of Tenite Polypropylene result in such injection-molded details as a leather-grained texture, clean ventilating slots, and sharp, three-dimensional lettering. And having the lightest weight of any solid plastic is its special contribution to portability.

This last property can often mean more finished pieces per pound—one of many economies found in Tenite Polypropylene. For example, its "built-in hinge" property (one sample flexed a million times without cracking) permits two-part articles to be molded as one piece, without need for conventional hinging. Another important saving results from the unusual strength of Tenite Polypropylene—products can have thinner walls.

Tenite Polypropylene may also be extruded into a wide variety of things—clear, printable, heat-sealable film...weather-resistant monofilament...sheet for thermoforming...insulation for wire...pipe for chemicals. And wherever color is important, Eastman offers more than 42,000 colors and color effects, in custom-compounded Tenite Polypropylene or in color concentrates for mixing with the uncolored plastic.

The advantages of Tenite Polypropylene may include several benefits for your product, and Eastman technical representatives and laboratory facilities are ready to help you find out. For details on this exciting new Tenite plastic, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE®
POLYPROPYLENE
an Eastman plastic

For more information, turn to Reader Service card, circle No. 337

Are Small Precision Metal Parts Getting In Your Hair?

If you need precision in small metal parts you can get it from Torrington—plus exactly the right finish, temper and hardness required for your needs. Moreover, Torrington can produce such parts at high speed and a remarkably economical cost. We are the leading specialist in this field—with the specialized skills, engineering experience and facilities to save you money. If you have small parts to be manufactured in large quantities why not let Torrington solve your entire problem. Let us hear from you and your request will receive prompt action.

progress through precision **SPECIAL METAL PARTS**

THE TORRINGTON COMPANY Torrington, Conn.

For more information, turn to Reader Service card, circle No. 388

ably our chances for the direct, large-scale generation of electric power. It makes possible a whole new generation of powerful atom smashers. It increases the possibility of a magnetic 'bottle' in which the vast energy of the hydrogen bomb reaction can be harnessed for useful power. It makes more feasible some of the far-out methods proposed for long-distance travel in space."

Westinghouse scientists are continuing research on magnets made of the columbium-zirconium alloy as well as on magnets made of other superconducting materials. The scientists say that "although considerable work remains to be done, there seems to be no fundamental metallurgical roadblock to the widespread development and use of superconducting magnets in the future."

For information on another superconductive magnet development, see p 206 in the Sept '61 issue.

Polyethylenes for Cable Shielding, Other Uses

Fifteen new and improved polyethylene resins have been placed on the market recently; five of the resins are designed for wire and cable shielding, two for extrusion coating on paper and other materials, and eight for extruded, injection molded and blow molded products.

1. Cable shielding grades

Three semiconducting polyethylene compounds, a semiconducting polyethylene resin and an extrusion grade polyethylene resin are designed for use as jacketing on communications and power cables.

The three compounds are available from Union Carbide Plastics Co., Div. of Union Carbide Corp., 270 Park Ave., New York 17, and the two resins are available from E. I. du Pont de Nemours & Co., Inc., Polychemicals Dept., Wilmington, Del.

The semiconducting nature of the three polyethylene compounds and the resin spreads an electrical charge over a large cable area; this distribution is said to greatly reduce the

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

How Alloy Steels Respond to Induction Hardening

In the induction-hardening process, steel is first heated above the transformation range by means of electrical induction, then quenched as required. Special equipment is needed, and heat is developed as follows:

High-frequency alternating current passes through a coil or inductor, with the result that a magnetic field is created in the coil. When the piece to be treated is placed in this field, it is heated rapidly by induced energy. With the various types of induction-heating equipment, the process is capable of surface- or case-hardening to various controlled depths; however, through-hardening can be obtained with certain alloy steels. Ferrous metals that respond well to induction hardening include numerous grades of both alloy and carbon steels, as well as hardenable stainless steel and plain or alloyed cast iron.

As a rule, when alloy steels which contain non-carbide-forming elements, such as nickel, are heated by induction, the usual hardening temperatures can be used. But with alloy steels that do contain carbide-forming elements such as chromium, molybdenum, and vanadium, the hardening temperature must be increased if the normal effect of the alloying elements is desired.

Hardness obtained by the induction process is a function of the carbon content and prior structure, just as it is when conventional heating methods are used. Nevertheless, higher surface-hardness values for a given carbon content have often been noted in parts subjected to surface induction-hardening. The extra hardness may be as much as five Rockwell C points for steels of 0.30 pct carbon.

As pointed out previously, the induction method requires special equipment. However, it possesses several marked advantages, including speed of heating and cleanliness of operation. Pieces heated by induction are usually subject to a minimum of scaling and distortion. Moreover, induction-hardening equipment is very compact and therefore conserves floor space.

If you would care to know more about the induction hardening of alloy steels, please communicate with our technical staff. Bethlehem metallurgists have made a thorough study of the subject, including the many details of quenching and tempering. Call them if they can help you in any way. And remember, too, that Bethlehem makes the full range of AISI standard grades, as well as special-analysis steels and all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

Steel

for Strength
. . . Economy
. . . Versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 405

LET MUELLER MAKE IT!

Mueller Brass Co. of Port Huron is much more diversified than the name "Brass" implies . . . a lot more. In fact, because of its many and varied facilities . . . its *men, methods* and *metals* . . . Mueller is in the unique position of being able to offer true single source service.

MUELLER HAS THE MEN . . . experienced engineers with the ability to work out, creatively, tough design problems, and improve a part or components for production by the most economical method. You get sound engineering plus 44 years of practical metalworking production experience when you "Let Mueller Make It."

MUELLER HAS THE METHODS . . . when you "Let Mueller Make It", you are utilizing one single source that is able to produce parts any one of these ways: as forgings, impact extrusions, sintered metal parts, screw machine products, formed tube or as castings.

MUELLER HAS THE METALS . . . and the materials . . . to produce precision parts in aluminum, brass, bronze, copper, iron, and steel in hundreds of different alloys to meet each exact requirement.

In addition, Mueller Brass Co. has complete and modern facilities for performing all types of finishing and sub-assembly operations. Another plus value is nation-wide sales engineering service.

So, in the final analysis, no matter where you fit in the American industrial picture, whether you're making missiles or mowers . . . and no matter where you're located, it will pay you to LET MUELLER MAKE IT!

MUELLER BRASS CO.
PORT HURON 21, MICHIGAN

For more information, circle No. 457

What's new IN MATERIALS

chance of a hole being blown in the cable jacket. Other favorable properties include toughness, flexibility at low temperatures, and good moisture, corrosion and chemical resistance.

Carbide's three compounds are based on a polyethylene resin that permits the incorporation of large amounts of conductive materials, while retaining most of the desirable properties of polyethylene.

DFDA-0520 is designed only for internal use in cables and is recommended as voltage stress relief shielding in high voltage cables. It can also be used as an electrical interference barrier or as a cable ground against lightning, the discharge being drained off before causing short circuits. Price: 65¢ per lb in truckload lots.

DFDC-5275 is designed for external cable jacketing and is expected to be used for lightning protection on multiconductor cables such as underground communications cables for missile sites. Properties of the new polyethylene include excellent stress-

Self-adhesive paper—A new self-adhesive paper can be used to protect soft or highly polished surfaces such as this piece of polished stainless steel during storage, handling and installation. A big advantage of the paper is that it leaves no sticky residue after removal. The material is available from Fasson Products, 250 Chester St., Painesville, Ohio.

KEY NO. 617

Wiley BOOKS—

PLASTICITY AND CREEP OF METALS

By J. D. LUBAHN, *Professor of Metallurgy, Colorado School of Mines,* and R. P. FELGAR, *in charge of Mechanics of Materials, Space Technology Laboratories.* Plastic flow and creep of metals—the deformation behavior of metals under stress and strain—is of increased importance today to the scientist and engineer working in fabrication and design areas. This new book focuses on what deformation behavior is and how to use its characteristics in solving engineering problems. The authors make it a point to use methods of analysis which do not require assumptions of material behavior not conforming to experimental results.

Multi-axial-stress and time effects are expertly covered, followed by material of a more advanced nature, including elastic creep, metallurgical changes, the Bauschinger Effect, and anisotropic plastic flow. Includes many problems, relating to specific practical situations. 1961. Approx. 656 pages. $16.75

OPTIMUM DESIGN OF MECHANICAL ELEMENTS

By RAY C. JOHNSON, *Yale Univ.* Presents a method of design which 1) is explicit in nature; 2) can be applied to innumerable problems; 3) minimizes cut-and-try; 4) accounts for inherently unavoidable limitations confronting designers. 1961. 535 pages. $11.50

MINERALS FOR THE CHEMICAL AND ALLIED INDUSTRIES

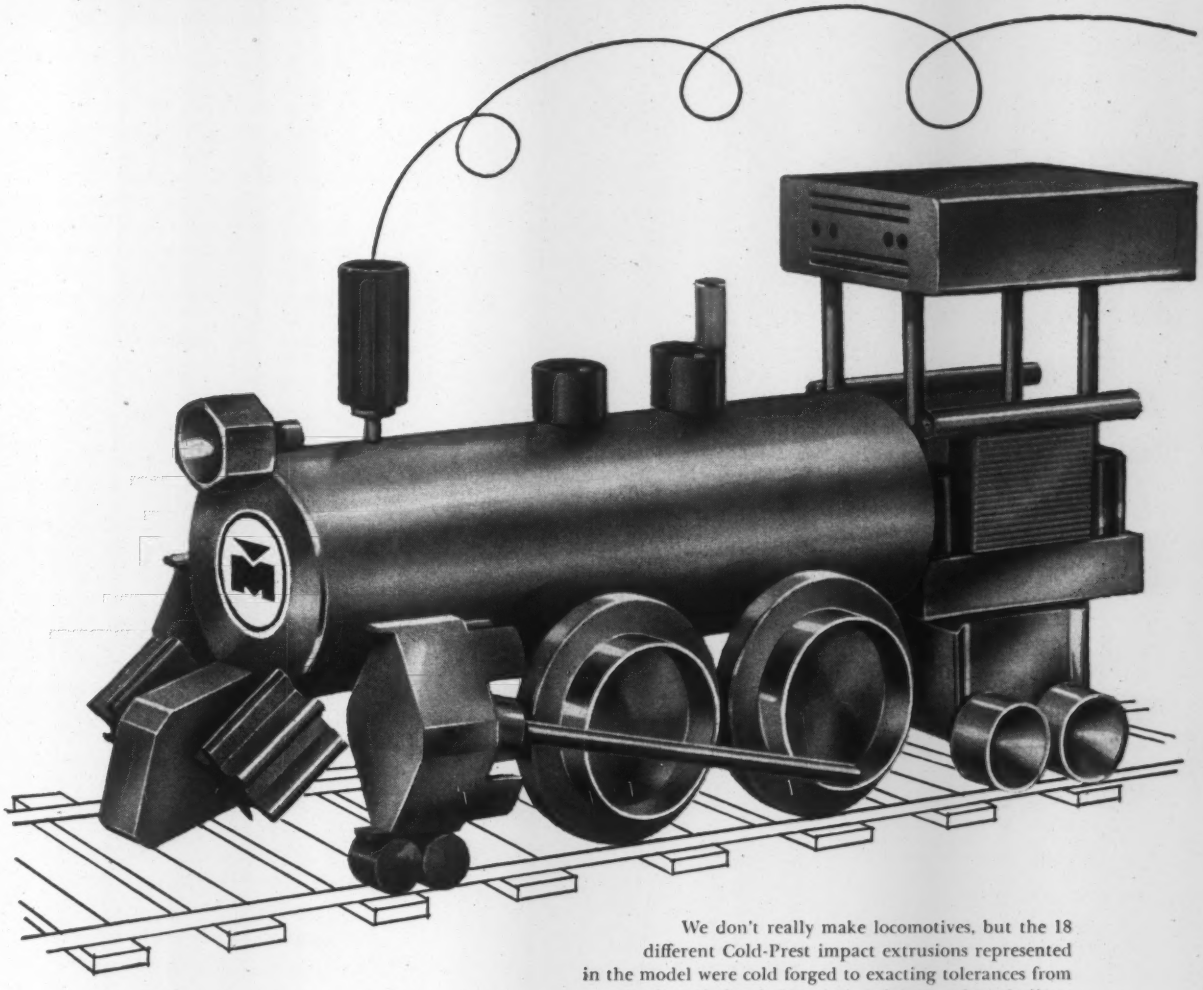
Second Edition, *By* S.J. JOHNSTONE *and* MARGERY G. JOHNSTONE. 1961. 787 pages. In Press

SEND NOW FOR YOUR ON-APPROVAL COPIES

JOHN WILEY & SONS, Inc.
440 PARK AVENUE SOUTH
NEW YORK 16, N. Y.

For more information, circle No. 368

MUELLER CAN MAKE MOST ANYTHING IN IMPACT EXTRUSIONS...



We don't really make locomotives, but the 18 different Cold-Prest impact extrusions represented in the model were cold forged to exacting tolerances from a number of aluminum, copper, brass, and steel alloys.

These parts are employed in products ranging from door closers to missiles. Mueller has also made important advances in the production of copper impact extrusions that are especially adaptable to electronic applications. Cold forgings are precision produced to exacting tolerances and offer the additional advantage of a better finish and appreciable metal savings.

Mueller's flexible facilities for the production of Cold-Prest Impact extrusions make practical long or short runs of simple or relatively complex shapes on an economical basis. In addition, the entire Mueller engineering staff, excellent machining, finishing and assembly facilities are readily available to you when you . . .

LET MUELLER MAKE IT!

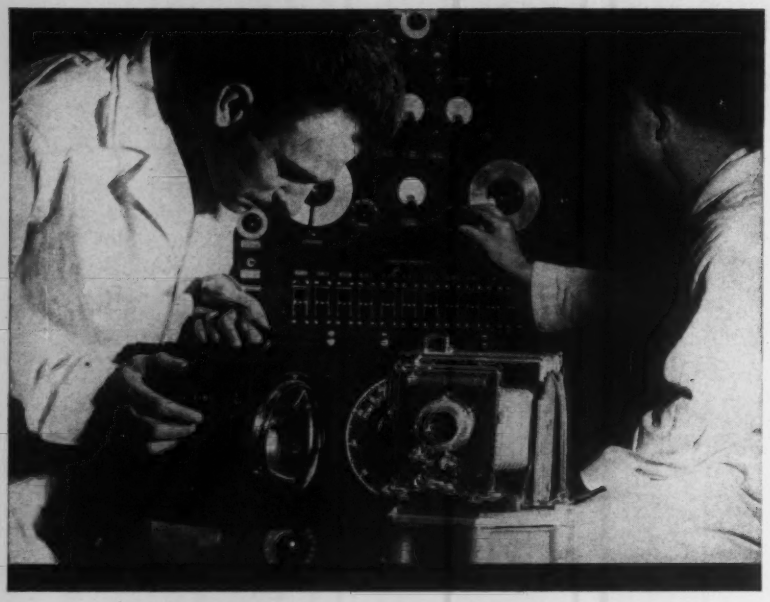
MUELLER BRASS CO.

PORT HURON 21, MICHIGAN

Write today for Engineering Manual No. FM-3019

344

For more information turn to Reader Service card, circle No. 457



It costs less to

RENT A LABORATORY

than to buy one

You can save costly investment in laboratory equipment and staff... and still get top-quality R/D services... by using the complete product testing and evaluation facilities of United States Testing Company. Since 1880 thousands of clients in all industries have used our services to get:

Improved Product-Design Through Testing

Our test engineers will set up an evaluation program that "locks in" with each step of your product development from design to prototype to finished product.

An Independent Laboratory

We present a completely objective, unbiased approach to your design evaluation problems. All reports to clients are impartial, factual and confidential.

Economical Handling of Peak Loads

We are equipped to take over your peak loads *immediately* at a fraction of what it would cost your company to maintain a staff of the necessary calibre.

Product Qualification

Tests run by United States Testing Company are recognized by military and government procurement agencies in placing a product on the Qualified Product list.

Facilities and Services

Mechanical Laboratory—evaluates mechanical, electro-mechanical hydraulic and pneumatic devices.

Environmental Laboratory—simulates high-low temperatures, humidity, altitude, immersion, salt spray, sand and dust, rain, fungus, vibration, shock, acceleration, etc.

Materials Testing Laboratory—conducts tension, compression and transverse tests on metals, ceramics, plastics, rubber and wood materials; spectographic analysis and X-ray also available.

Electronic Laboratory—evaluates electronic components and systems in communications and industrial fields; includes automated facilities for low-cost collection of reliability data.

Chemical Laboratory—covers all fields including physical and biological chemistry; also infrared spectrophotometry.

Send for your free copy of bulletin 5801 describing our complete services and facilities.

The World's Most Diversified Independent Laboratory.

United States Testing Co., Inc.

1415 Park Avenue, Hoboken, N. J.

Branch Laboratories BOSTON • CHICAGO • DALLAS • DENVER • LOS ANGELES MEMPHIS • NEW YORK • PHILADELPHIA • TULSA

For more information, turn to Reader Service card, circle No. 438

What's new IN MATERIALS

cracking resistance, low temperature impact, and good elongation characteristics over a wide temperature range. Price: 65¢ per lb.

DHDA-7800 is recommended for external jacketing where a moderate degree of conductivity is required, according to Carbide. The compound has a volume resistivity less than 50 ohm-cm, excellent stress-cracking resistance, good impact strength, and good low temperature properties. Price: 50¢ per lb. **KEY NO. 612**

Alathon 2900 BK 50 is the name of Du Pont's semiconducting polyethylene resin. Developed to meet requirements of the Minuteman missile, the high density resin is used primarily as an electrostatic shield on insulated wire and cables for control and communications. Price: 65¢ per lb in truckload lots.

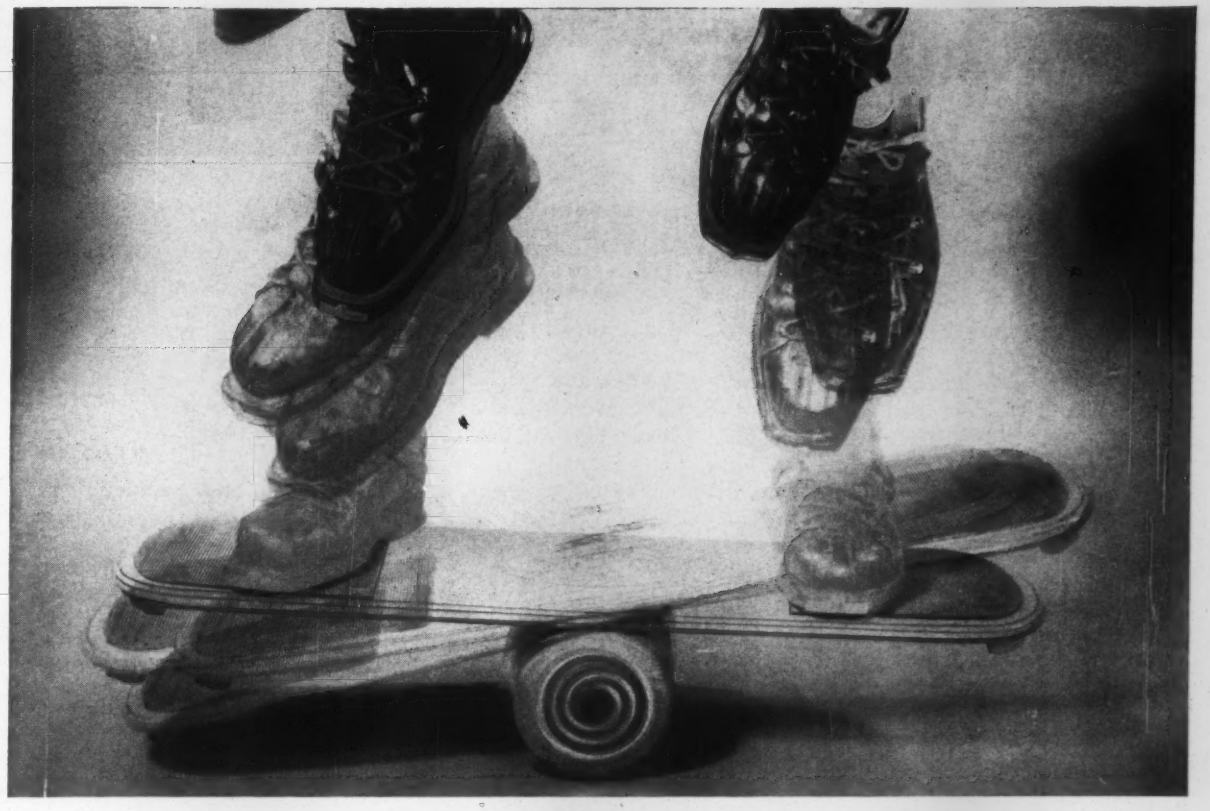
Alathon 3530 is another new polyethylene from Du Pont designed as a cable insulation. The resin can be extruded to give telephone and control cables exceptionally smooth insulation coatings at speeds up to 4000 fpm. Wire insulations produced from the resin are said to have excellent electrical properties, toughness, good aging properties, flexibility at low temperatures, and good moisture resistance. Price: 33¢ per lb. **KEY NO. 613**

2. Extrusion coating grades

The two polyethylenes designed for extrusion coating on paper and other materials can be run at high speeds.

Marlex TR-515 is an extrusion-grade coating resin available from Phillips Chemical Co., Bartlesville, Okla. It is expected to be used for coating paper bags, films and foils where low moisture vapor transmission and grease-proofness are necessary, and paperboard products such as folding boxes. The high density polyethylene is said to have good resistance to scuffing, temperature extremes, moisture and grease. It has

PROPERTIES of most engineering materials can be found in the fifth edition of M/DE's *Materials Selector Issue*, published in October. Names and addresses of suppliers are also listed in this unique publication.



How wood engineering helps improve skiers in July

THE "BONGO BOARD" (above) is an exercise and balancing device which, among many other recreational uses, is popular with skiers as an off-season training aid.

When Bongo Corporation came to Gamble Brothers, seven years ago, they needed a supplier who could produce platforms and rollers which would retain dimensional stability despite repeated twisting and hard pounding; which would not scuff carpets or damage floors when used inside; which would operate smoothly and quietly; and which could be produced at low unit cost. Gamble Brothers' facilities and experience "filled the bill" then, and still do now.

Problems like this are "all in a day's work" to the wood engineers at Gamble Brothers—a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4627 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS, INC.

4627 Allmond Avenue, Louisville, Kentucky

For more information, turn to Reader Service card, circle No. 441

Available Now!!

Reprints of

MATERIALS IN DESIGN ENGINEERING MANUALS AND SPECIAL REPORTS

Because of the great demand for the well-known Manuals and Special Reports that are widely used for reference purposes, MATERIALS IN DESIGN ENGINEERING has reprinted them for your use. These outstanding articles provide you with complete and useful information on the properties, characteristics and uses of engineering materials and finishes.

The price is right! Only 35¢ for each reprint; 40¢ if shipped to foreign countries. On quantity orders, discounts are offered. To obtain your copies, indicate in the handy coupon below the Manuals and/or Special Reports you want. FOREIGN ORDERS MUST BE ACCOMPANIED BY PAYMENT!

Would you prefer receiving these valuable reprints automatically in the future? If you are a subscriber to MATERIALS IN DESIGN ENGINEERING, then avail yourself of an additional service offered by our Reader Service Department. Let us add your name to our mailing list, and you will receive a year's supply of Manuals and/or Special Reports for the reasonable price of $4.50* per year. Just fill out the coupon below and mail it to:

Reader Servce Department
MATERIALS IN DESIGN ENGINEERING
430 Park Avenue
New York 22, N. Y.

▼ **Quantity @ 35¢ each**

....Selecting Plastic Laminates
....Magnesium and Its Alloys
....Conversion Coatings for Metals
....Mechanical Tubing
....Joining & Fastening Plastics
....Aluminum Alloy Castings
....Designing with Heat Treated Steels
....Porcelain Enamels, Ceramic Coatings
....Paper as an Engineering Material
....Designing Metal Stampings
....Sleeve Bearing Materials
....Sheet Formed Plastics Parts
....How to Select a Stainless Steel
....Engineer's Guide to Plastics
....Organic Coatings for Metal Products
....Designing with Metal Powder Parts
....Physical Properties & Tests
....Industrial Textiles
....Materials for Springs
....Adhesive Bonding
....Die Castings
....Impact Thermoplastics
....Material for Gaskets—Packing—Seals
....New Welding Processes
....Low Pressure Reinforced Plastics
....Low Cost Coatings for Metal Parts
....Why Metals Break; What to Do About It
....Appliances: What Materials Are Next?
....High Temperature Metals
....How Radiation Affects Materials
....Filament-Wound Reinforced Plastics
....Ferrous Castings
....Automobiles: What Materials Are Next?
....What Users Think of Polypropylene
....Creep Rupture
....Chemical Process Equipment
....What's New in Foam Plastics
....High Strength Aluminum Alloys
....The Role of Materials in Cryogenics
....New Look at Prefinished Materials
....The Future for Ceramics
....New Ways to Strengthen Metals
....High Temperature Coatings for Metals

....The Challenge of the Materials Age—PRICE $1.00
....New Directions in Materials Testing—PRICE 75¢
....Guide to Materials Standards & Specifications—PRICE 75¢

Name.....Title.....
Company.....
Street.....
City.....Zone.....State.....

☐ Yes, I am a subscriber to MATERIALS IN DESIGN ENGINEERING and would like to receive each future Manual and/or Special Report, when reprinted. Please start with the..... issue. Upon receipt of your invoice, I will pay $4.50 for a year's supply. **Foreign subscriptions—$5.50.*

What's new IN MATERIALS

a coating rate of 600 fpm.

KEY NO. 614

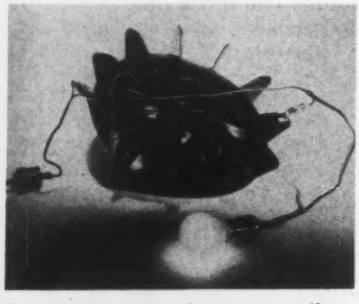
Alathon 3425 BK 22 is Du Pont's new polyethylene resin designed for extrusion coating. The resin contains 2½% carbon black to provide opacity and good weatherability. It can be processed at speeds up to 1000 fpm and at temperatures over 625 F.

KEY NO. 615

3. Injection, blow molding

The eight high density polyethylene resins for extrusion, injection and blow molding applications have been introduced by Dow Chemical Co., Midland, Mich.

R600, R800 and R810 are designed for injection molding and extrusion applications that require materials with good flow properties. R600 is recommended for applications requiring a combination of moldability and toughness, such as automotive parts. R800 is recommended when mold fill is a problem, rigidity is desirable, warpage must be held to a minimum, and impact strength or extreme toughness is not a prime requisite. R810 is a polyolefin copolymer de-

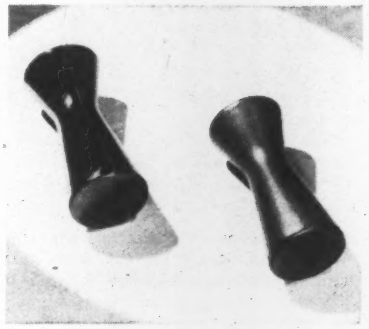


Conductive plastic—A new fiberglass-reinforced polyester molding compound was used to make this electrically conductive part. Introduced by Glastic Corp., 4321 Glenridge Rd., Cleveland 21 and called Grade X-1011-F, the premix can be molded into parts for use in explosion-proof equipment, textile machinery, chemical process equipment and surgical devices. The molded compound has a tensile strength of 5000 psi, flexural strength of 16,000 psi, and a notched Izod impact strength of 5 ft-lb per in. It sells for 63 to 69¢ per lb, depending on quantity.

KEY NO. 618

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Matte finish for molded parts**
- **Phenolic for blowers**
- **Fire-safe, bakable reinforced polyester**



NORTON LABORATORIES, INC.

Want less gloss?

For years we've trumpeted the virtues of the high gloss that's characteristic of phenolic molded parts.

Gloss, however, is not always a plus. In certain precision instruments, gloss translates into *glare*. Sometimes, too, a consumer product can gain esthetically from the satiny look and feel of a matte finish.

One custom molder, Norton Laboratories, Inc., has developed a special process for putting matte finishes on compression-molded phenolic parts, as on the double-duty lamp handle-switch above. In some instances, the finish takes the place of a painting operation and so lowers cost.

The plastic molder now supplying this type finish is Norton Laboratories, Lockport, N. Y. We suggest that you write to them directly for quotations on plastic parts you need incorporating this finish.

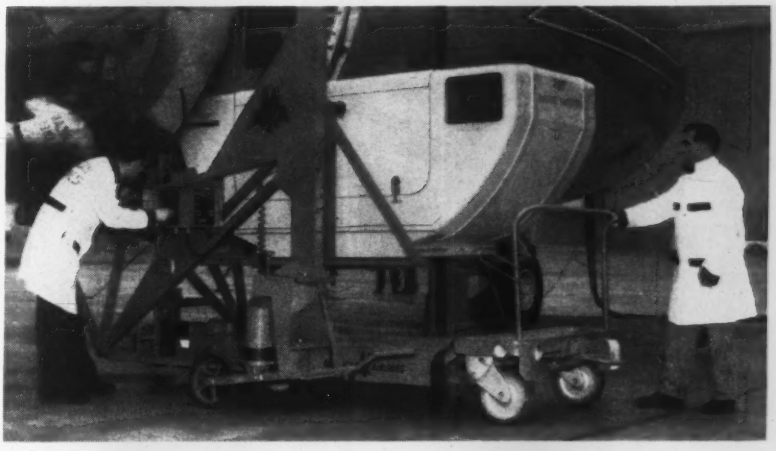
Move air at low cost

Note the economy of design in this blower and duct assembly for an automatic washer-dryer. Why use more pieces when three will do?

Note, too, how economy begets economy. Very few assembly operations. Few rejects, because these phenolic parts can't get bent and won't warp. No balancing needed in the blower wheel, because concentricity is molded in. Wobble is much less than could be achieved at low cost in a metal wheel.

Phenolic is functionally right for air-moving jobs, especially if they also involve heat: a small hair dryer, a big circulating fan, or just about anything between. Inexpensive general-purpose molding compound serves adequately, as a rule: withstands moisture and mild corrosive atmospheres; is unbothered by temperatures up to 300°F; even resists flame spread; operates for years without rattling, drumming.

Your molder of thermosetting plastics can probably help *you* achieve such economy, whether in a blower or some other part you're working on. To get more ideas on where and how to use phenolic molding compounds, send in the coupon, requesting Durez Bulletin D400.



The different polyester

Cutting across the currents and countercurrents of talk about reinforced polyester plastics are two incontrovertible facts:

1. You can get a polyester molding material that's *inherently and permanently self-extinguishing.*
2. This same polyester can take a baked-on finish without surface craze.

Its name is Hetron.® The self-extinguishing trait does not come about as a result of diluting the plastic's strength with additives. It's there to begin with, in atoms of chlorine welded tightly into the resin molecule. That's why it lasts.

So much for chemistry. The craze resistance takes longer to explain, but matched-die molders know they can count on it for structural shapes that must undergo a 90-minute bake at 350°F.

Superimpose these two truths on the other advantages of strong, lightweight polyester construction, and you can appreciate why Hetron is helping so many designers give shape to new ideas. This luggage pod for a jet airliner is one case in point. Others include 65-foot radomes, factory skylights, large boat hulls, outboard-motor shrouds, chemical ducts and vessels, transformer housings, heavy-duty switch-gear components.

If you'd like to know more about this versatile material, check the coupon for designer's Hetron data file.

For more information on Durez materials mentioned above, check here:

- ☐ Phenolic molding compounds (8-page Bulletin D400)
- ☐ "Durez Plastics News" (a review of current plastics applications, mailed bimonthly)
- ☐ Hetron polyester resin (data file and list of fabricators)

Check, clip and mail to us with your name, title and company address.

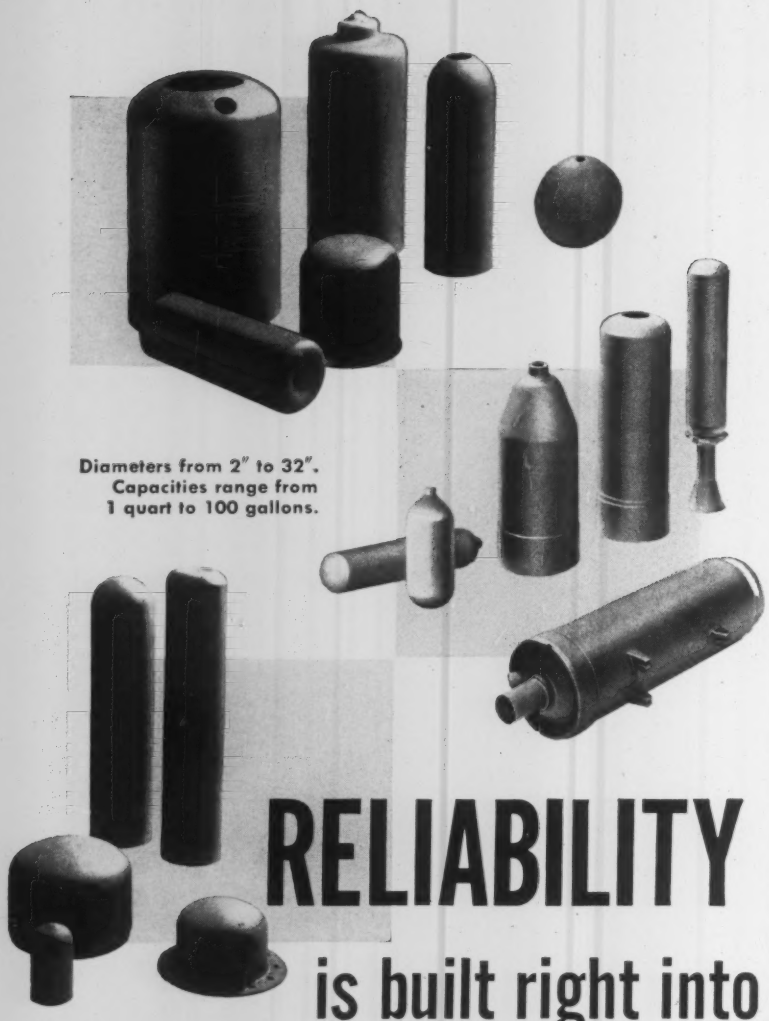
DUREZ PLASTICS DIVISION

1411 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

For more information, turn to Reader Service card, circle No. 393



Diameters from 2" to 32".
Capacities range from
1 quart to 100 gallons.

RELIABILITY is built right into Hackney-made components

Hackney forming methods produce strong, lightweight, seamless shells the cold drawn way. With smooth, clean surfaces, consistently uniform side walls and closely controlled tolerances, performance reliability becomes an integral part of every Hackney deep drawn shape or shell.

You will find plenty of design latitude in our methods because we make available to you a vast assortment of dies, mandrels and related tooling to match your ideas. Units can be made in sizes from 1 qt. to 100 gal. Diameters range from 2" to 32". Lengths may be from ½ to 5 times the diameter, or up to 110"...working pressures to 10,000 psi, depending on diameter.

Hackney experience and facilities can form your components in steel, magnesium, nickel, ultra-high-strength stainless steels, hot work tool steels, molybdenum or titanium. Let our engineers help you work out details and suggest ways to improve reliability...reduce cost. For complete information, write to the address below:

Pressed Steel Tank Company

Manufacturer of Hackney Products Since 1902

1442 South 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

Hackney Wellington Iron Works

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service card, circle No. 386

What's new IN MATERIALS

signed for applications requiring good load bearing properties over an extended period of time, good low temperature properties, and excellent moldability.

R211 and R401 are designed specifically for blow molded containers. R211 is a copolymer characterized by excellent resistance to stress cracking and good rigidity. R401 is an ethylene homopolymer with excellent rigidity and impact strength.

R200, R210 and R300 are general purpose high density polyethylenes suited for both blow molding and extrusion applications. R200 and R300 are ethylene homopolymers that provide excellent rigidity and impact strength.

Three of the Dow resins, R200, R210 and R211, sell for 35¢ per lb in truckload lots. The other five formulations sell for 32¢ per lb.

KEY NO. 616

High Luster Sheet for Light Reflectors, Trim

A highly reflective metal sheet can be bent, drilled, punched, crimped and formed into a variety of shapes for use as light reflectors and decorative trim for radio and TV cabinets, autos and vending machines.

The material consists of metal-

***Mirror-like finish** on new reflective metal sheet is produced by bonding metallized polyester film to aluminum with a high strength adhesive.*

the LEAD newsletter

Vol. 3 No. 4

Quiet Triumphs of Lead—In Soundproofing

The battle against noise continues to concern industrial management. Fatigue and accident hazards aggravated by high noise levels cut into production capability and pose critical personnel problems. From time to time this Lead Newsletter has dealt with particular uses of lead and leaded products in soundproofing. Here, to complement those reports, is an account of new lead developments and successes in fighting din and clamor.

Quieter Rooms and Buildings

Sheet lead has been recommended and used to block sound transmission because of its high mass and low stiffness. Acoustically deficient walls have been brought up to requirements by panelling them with sheet lead over a light fibrous material or simply over furring strips. One Australian firm erected a construction shanty at the site of a new office building under construction and used walls of hollow panels with sheet lead membranes in the center. The panels were faced with 5/16" hardboard and measured 8' x 3' x 2" thick. The sheet lead was 2 pounds per square foot. The floor and roof also used 2 lb. sheet lead and the windows were double glazed. The strong preference of the draftsmen for the sound treated room was backed up by sound measurements—a 31 decibel transmission loss in the treated room vs. a 24 decibel drop in an adjacent room of similar, though unleaded, construction. This seven decibel difference is interpreted as about a halving of the noise level.

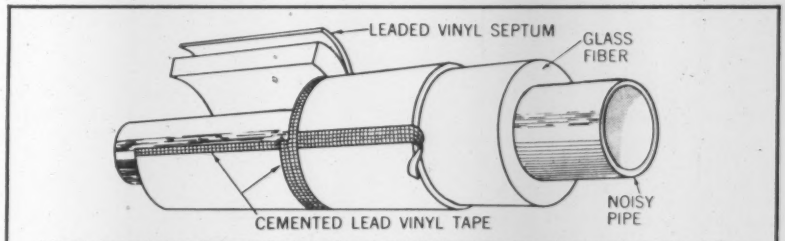
Folding Doors and "Window Shade" Walls

For large rooms that must be divided to afford acoustical privacy to several groups but retain their capacity for holding large meetings, there are two new leaded plastic soundproofers. One of these is similar to conventional folding doors. Faced with vinyl coated fabric in decorator designs it forms a smart modern wall when extended. It can also be folded back to a fraction of its extended length when both sections of the room are to be joined. Inside the door, two sheets of lead-filled vinyl weighing 70 oz. per square yard (slightly less than ½ lb. per sq. ft.) each, block the sound transmission. Acoustical tests that rated average wooden doors at 18 to 20 decibel showed the folding door to have 33.5 to 39 decibel of sound transmission loss.

A more novel leaded vinyl product for dividing large rooms is a ceiling-hung curtain which is raised and lowered like a window shade. Tests of this wall show 32 decibel transmission loss. One major market for such a device is in new school construction. Those considering the curtain for meeting rooms may want to note that it has built-in roll-up chalkboards.

Upgrading Diverse Products

The list of products now taking advantage of lead for sound and noise control is growing, too. Aircraft manufacturers make use of leaded vinyl and other soft plastics with high lead contents to quiet cabins of helicopters and commercial jetliners. Work done to provide a reasonably quiet Sonar environment in anti-submarine helicopters has been carried over into commercial passenger models soon to come into airport-to-airport and airport-to-center-city shuttle service. For military and civilian personnel who must work with the big jets at landing fields, a set of molded phenolic "earmuffs" embodying lead has recently won the highest accolades. Electric typewriters and other office equipment are now employing a whole family of novel leaded plastics to mute their noise. They gain a further benefit in sales appeal because of their obvious excellence of construction and their air, unconsciously created, of quiet efficiency. Among the newest technical developments is a sound deadening paint which has proved itself in quieting complex machines. It carries a high lead loading in a Hypalon® base.



Leaded vinyl and glass fiber covering is used to slash noise levels in pipes at pressure reduction stations.

Taming the Roar of Industry

Several gas pipe line pressure reduction stations have made use of similar leaded vinyl sheet to quiet the indescribable roar of gas being dropped from pipeline pressure (typically 150 psi) to consumer pressure (typically 15 psi). Ports in the pressure regulating valves act as noise generators and sound measurements show that sound levels of 110 to 130 decibel are not unusual at such a station. For reference, a large jet at takeoff generates 140 to 160 decibel, a subway train 90 to 100 decibel.

By covering the pipes and valves with a blanket of glass wool about 2 in. thick and covering this with leaded vinyl 0.055 in. thick (0.87 lb./sq. ft.) the noise level was dropped 30 decibel. Of course this does not meet library reading room standards, but conversation and work are possible.

For technical information and help in applying lead to your own products and problems, simply write: Office of Technical Information, Lead Industries Association, 292 Madison Ave., New York 17, New York.

LOOK AHEAD WITH LEAD

For more information, turn to Reader Service card, circle No. 465

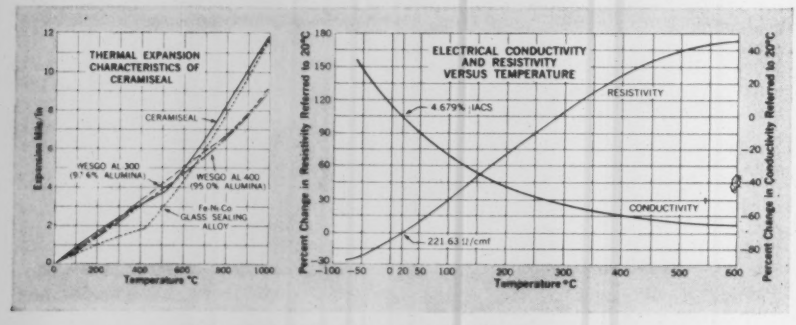
WBD CERAMISEAL®

The Better Metal for HIGH ALUMINA CERAMIC SEALING

CERAMISEAL (U. S. Pat. No. 2,960,402)

Chemical Analysis: 25% Cobalt, 48% Iron, 27% Nickel

Specially designed by WBD for ceramic-to-metal sealing, CERAMISEAL alloy has expansion characteristics closely matching those of high temperature alumina ceramics. Low thermal conductivity, approximating that of ceramics, minimizes thermal stresses during rapid heating and cooling cycles. CERAMISEAL is readily brazed, deep drawn and machined; is supplied (air or vacuum melted) in wire or strip.



Call or write for Ceramiseal Bulletin and information on other WBD Sealing Alloys.

WILBUR B. DRIVER COMPANY

NEWARK 4, NEW JERSEY — Telephone: HUmboldt 2-5550

In Canada: Canadian Wilbur B. Driver Co., Ltd., 50 Ronson Drive, Rexdale (Toronto)

PRECISION RESISTANCE, ELECTRONIC AND MECHANICAL ALLOYS FOR ALL REQUIREMENTS

For more information, turn to Reader Service card, circle No. 384

What's new IN MATERIALS

lized polyester film permanently bonded to aluminum sheet. Called Dynasyl, the sheet is available from W. J. Ruscoe Co., 483 Kenmore Blvd., Akron, Ohio in thicknesses from 0.015 to 0.090 in.

According to the developer, the high luster, mirror-bright finish has exceptional resistance to most acids, alkalis, greases, oils and solvents. Outdoor weathering and salt spray have no harmful effect on the material. The material withstands temperatures up to 275 F for long periods.

The permanent adhesive bond between the metallized film and the aluminum subsurface permits the material to be shaped to severe extremes without impairing the reflective surface. The plastic covered sheet can be formed in standard metalworking equipment, with no special heating systems required.

KEY NO. 619

Vinyl Fluoride Tape

A new pressure sensitive polyvinyl fluoride tape is said to have excellent weatherability and chemical resistance, toughness, and good electrical properties.

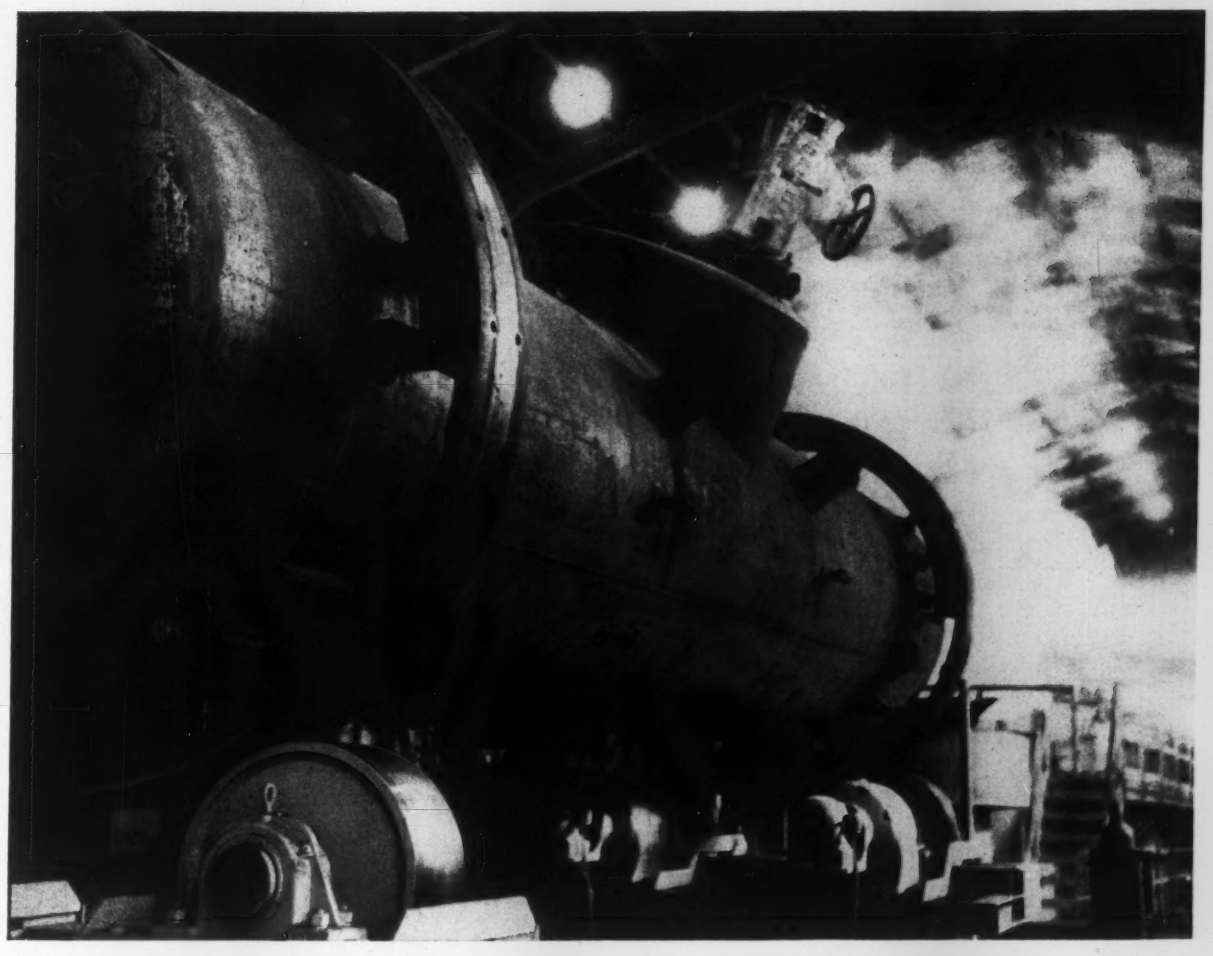
Called Temp-R-Tape PVF, it is available from Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn. in 1-in. wide by 5-yd long rolls at $5 per roll.

The new tape has a silicone rubber adhesive on one side. It is suggested for use as an electrical insulation and as a protective covering for a variety of electrical and nonelectrical products. **KEY NO. 620**

Transparent Coatings for Aluminum Foil

A new line of colored, transparent coatings is designed to protect aluminum foil against weathering, staining and water. Called Stromiset, the thermosetting coatings are available from Revere Copper and Brass Inc., Foil Div., 230 Park Ave., New York 17, N. Y.

According to the developer, the cured coatings can be bent, cut,



The specialists at General American's Kanigen plant in Sharon, Pennsylvania can deposit an even coating of hard nickel alloy on most ferrous metals in common use. Regardless of how high, wide or heavy the object is, if you can get it to Sharon, we can plate its interior.

Before General American developed Kanigen coating, it was next to impossible to deposit an even nickel plating over very large surfaces or on many complex shapes. Since Kanigen nickel plating is purely a chemical process involving no electric current, it works equally well on simple or complex shapes and on small or large surfaces. Thickness uniformity of the coating is independent of part complexity or size.

Only General American and its authorized licensees around the world can show you how Kanigen coating may improve your product. The Kanigen process is protected by more than 30 separate patents. For detailed technical literature, write for bulletin No. 561.

IF YOU CAN SHIP IT WE CAN PLATE IT!

NO MATTER WHAT THE SIZE OR SHAPE OF YOUR PRODUCT, IT CAN BE COATED BETTER WITH KANIGEN® NICKEL ALLOY

Kanigen Division

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle Street, Chicago 3, Illinois

Offices in principal cities

KANIGEN GENERAL AMERICAN TRADE MARK

For more information, turn to Reader Service card, circle No. 413

UNCOMMON from UNCOMMON

Specialists in CLOTH from METALS

PLATINUM
GOLD-SOLID
GOLD-PLATE
MOLYBDENUM
SILVER
TANTALUM
TITANIUM
TUNGSTEN

And not only do we weave mesh cloth in these metals to order but we carry some items in stock. We also fabricate inserts, strainers and other parts to order, utilizing our own 'uncommon' mesh cloth.

Why not phone us—Newark, N. J. HUmboldt 3-7700—regarding your requirements for wire cloth made of an uncommon metal? It will expedite matters and we might be able to help you in your selection.

As background for this kind of work, we can point to more than fifty years of wire cloth making, during which time we have made cloths of practically every metal that can be drawn into weavable wire.

NEWARK for ACCURACY

Newark Wire Cloth COMPANY

351 Verona Avenue • Newark 4, New Jersey
Teletype: NK607 • Tel.: HUmboldt 3-7700
Representatives in all principal industrial areas

For more information, turn to Reader Service card, circle No. 416

flexed, creased and formed without damage.

Foil protected with the coatings (composition undisclosed) is expected to be used in outdoor and indoor advertising displays and pie plates. Another use is as a decorative material in the form of small chips in floor coverings and acoustical tile.

KEY NO. 621

Mica Paper Tubing Useful up to 1500 F

Rigid mica paper tubing with extremely thin walls has been introduced by Mica Insulator Div. of Minnesota Mining & Mfg. Co., Schenectady 1, N.Y.

Called Isomica 6T, the tubing keeps its electrical and physical properties at operating temperatures up to 1500 F. It has low water absorption, good radiation resistance and good arc resistance.

The tubing is expected to be used for heating element bushings in electric ranges, coil forms, resistor and transformer cores, and space battery shields. A current use is as a thermal and electrical insulation in a tiny thermoelectric generator for space satellites.

The new tubing is available in lengths up to 18 in., with o.d.'s ranging up to 4 in.; minimum i.d. is ⅛ in. and minimum wall thickness is 0.010 to 0.012 in.

KEY NO. 622

Tubular Steel Sold in Wide Range of Shapes

Tubular shapes of stainless steel having a wide variety of exterior and interior configurations are available from H. M. Harper Co., Metals Div., Morton Grove, Ill. Previously, the company produced only solid shapes.

Ugine-Sejournet process used

The tubular shapes are made by a variation of the French-developed Ugine-Sejournet process which was introduced about 10 years ago. The Ugine-Sejournet process uses a glass lubricant to extrude finished shapes

1,000,000 blows a day into solid rock

Nickel alloy carburizing steels sustain powerful punch of heavy-duty drill.

Every working day this G-900 Tracdril* hammers its bit deep into solid rock. Connecting the drill motor and the bit is a string of steel which must take the torturous impact of more than 25 blows per second without failing. To meet this stern requirement Chicago Pneumatic engineers specify nickel alloy carburizing steels for the most critical parts.

In the chuck end of the drill, where the punishment is most severe, carburized and hardened AISI 3312 (3.5% Ni, 1.5% Cr) is used. Parts made of AISI 3312 withstand severe compressive loading and wear resistance, because under heat-treatment they develop a surface hardness of 60 Rc min. coupled with a core hardness of 35-40 Rc.

In the drill feed motor rotor and the rifle bar and striking bar of the drill AISI 4620 (1.8% Ni), provides excellent strength and toughness. To take high shock loads and heavy wear, these parts are carburized and hardened for a tough, impact-resistant core beneath a hard case. AISI 4620 provides minimum distortion during heat-treatment and at a hardness of 60 Rc can handle compressive loads of 200,000 psi.

AISI 3312 and 4620 are just two of many nickel alloy steels that handle rugged jobs in all sorts of heavy-duty equipment. They last longer, perform better, and can be fabricated at practical cost. If you'd like help with your problems in the selection of alloys, simply write to Inco describing them.

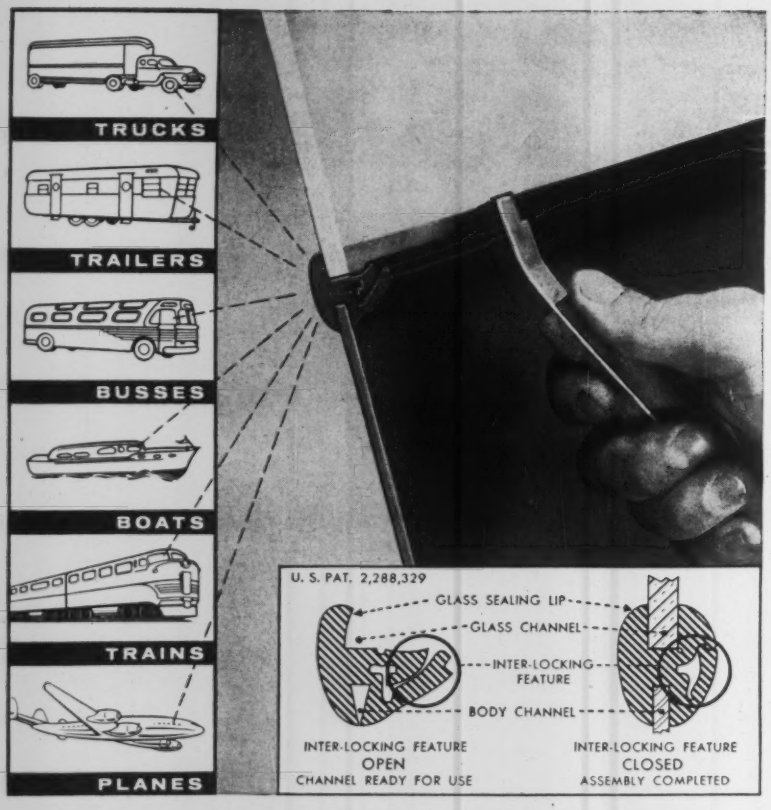
*T.M. Chicago Pneumatic Tool Co.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

MAKES STEEL PERFORM BETTER LONGER



Self-Locking Rubber Channel for Mounting Glass in Body Panels

Its *one-piece* design locks and seals in one operation. No extra locking-strip needed. It's the faster, simpler method for mounting glass in any type body panel—truck, trailer, bus, boat, train, plane, etc.

Extruded with inter-locking feature at direct right angle to body, the Continental Channel permits unhampered insertion of glass. Locking tongue is pressed into its matching groove which forces the lips against *both* the glass and body panel—a more positive seal with exceptional push-out pressure.

Compounded for maximum weather resistance and extra long life. Close durometer tolerances are held for uniformly tight seal against moisture and surest possible locking. These rubber channels can be positioned first on *either* glass or body panel. All details are shown in illustrated brochure gladly sent on request.

Ordered and re-ordered by the most prominent body builders, this Self-Locking Channel is another example of the creative thinking and ingenuity behind rubber parts by Continental. When you need rubber parts to do a specific job, call a rubber specialist *during the planning stage.* This often makes for economy as well as better end results. Call Continental —rubber specialists since 1903.

Engineering catalog.

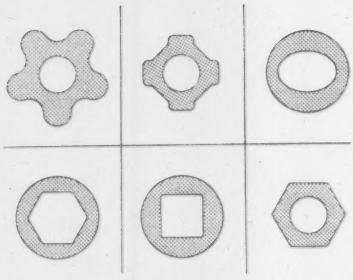
In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1985 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 443

What's new IN MATERIALS



Cross sections *of some of the wide variety of extruded stainless shapes being produced by a variation of the Ugine-Sejournet process.*

directly from the billet without rolling.

The tubular shapes are made with o.d.'s ranging from 1½ to 3 in. They are expected to be used for connecting rods, impellers and various types of shafting. **KEY NO. 623**

Noted briefly in our October issue.

New Phenol Makes Phenolics Flexible

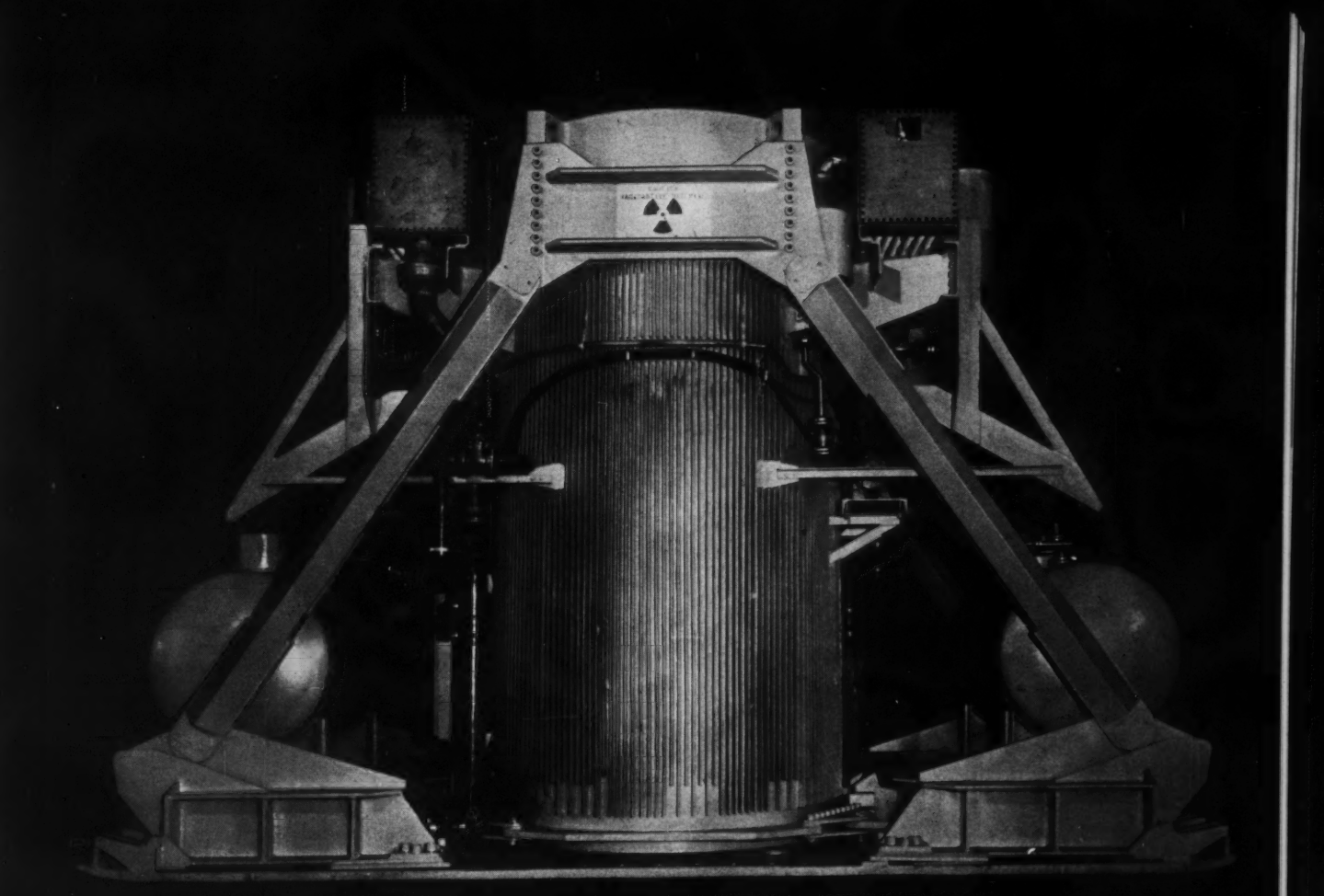
Permanently flexible phenolic resins have been made possible with the introduction of a new phenol by the Tar Products Div. of Koppers Co., Inc., Koppers Bldg., Pittsburgh 19. It is called Flexiphen 160.

Overcomes brittle cure

The normally brittle cure of phenolic resins is overcome in the new phenol by replacing some of the single-carbon methylene linkages between phenolic groups with longer hydrocarbon chains. This results in less rigid intermolecular bonds that permit the resin molecules to flex, bend and move about while retaining the other desirable properties of phenolic resins.

Other advantages of phenolic resins made with the new phenol:

1. Improved preheatability, which reduces premature burning losses.
2. Lower specific gravity, which gives about 5% more parts per pound of molding compound.
3. A 30% increase in impact



for safety's sake there's Carlson Stainless Plate in this Spent Fuel Shipping Cask

One of a group of Spent Fuel Shipping Casks designed and fabricated by Knapp Mills Incorporated for General Electric Company.

Photo courtesy of Knapp Mills Incorporated.

Spent atomic fuel is "down but not out." Containing unused uranium, it still must be handled safely and surely in being moved by rail, boat, or truck to recovery stations throughout the country.

Carlson Type 304 stainless steel plate was used in various parts of these shipping casks. Designed and fabricated by Knapp Mills Incorporated of Wilmington, Delaware, each cask weighs approximately 125 tons.

For maximum assurance—whether you build chemical, process, nuclear, missile, or aircraft equipment—specify dependable Carlson stainless steel plate. Specialists produce the material to meet your exact specifications. Your fabrication is easier—true-up and finish-welding is done quickly and efficiently. This, plus prompt delivery, is the total Carlson service you can count on—write, wire or phone today for complete information and assistance.

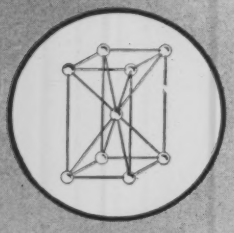
G.O.CARLSON Inc.

Producers of Stainless Steel

126 Marshallton Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

Plates • Plate Products • Heads • Rings • Circles • Flanges • Forgings • Bars and Sheets (No. 1 Finish)

For more information, turn to Reader Service card, circle No. 452



TIN COATING from .00002 to .0025

Somers THIN STRIP

For the first time tin coated thin strip is available in solderable coatings up to .0025" thick.

Pure tin and tin-lead alloys are now coated on copper, brass, or nickel in all gauges from .002 to .012 in thicknesses of .00002 to .0025.

Over 50 years experience in the highly specialized field of thin strip makes Somers your #1 source for that one job in ten that must meet rigid specifications. Write for confidential data blank to get the exact thin strip for your requirements — no obligation, of course.

SOMERS BRASS COMPANY, INC. • 94 Baldwin Ave., Waterbury, Conn.

For more information, turn to Reader Service card, circle No. 444

strength, which reduces chipping losses on finished parts.

Used in laminates

Phenolic resins made of the new phenol are expected to find use in laminates, insulating varnishes and pigmented systems. Laminates made from the resin have excellent cold punching properties. Thin laminates such as those used in portable radio circuits are significantly less susceptible to cracking or shattering when dropped, according to the producer.

The advantages of flexible phenolics should also prove valuable in laminated rods and tubing.

Noted briefly in our August issue.

KEY NO. 624

Tin-Lead Solder

A new tin-lead solder is said to be significantly more free from oxide forming elements than other commercially available tin-lead solders. As a result, the solder cuts dross, increases bath life, reduces inherent inclusions, improves wetting and produces brighter joints.

The solder is made by special, proprietary techniques, details of which have not been revealed. Called Vaculoy, it is marketed by Alpha Metals, Inc., 56 Water St., Jersey City 4, N. J. It is available from stock in most of the common tin-lead alloys, and is sold in standard 1-lb bars and 9-lb ingots for automatic soldering machines.

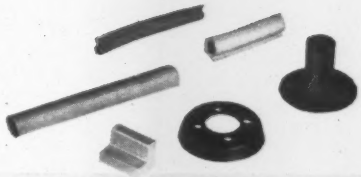
Field tests indicate that the new solder has been effective in cutting printed circuit joint rejects from 8 in 400 to 1 in 5000. KEY NO. 625

Treated Nylon Fabric for Rocket Applications

A nylon reinforced phenolic for rocket applications has been introduced by Taylor Fibre Co., Norristown, Pa. It is sold as a prepreg in the form of sheets, rolls and cut squares and as molded sheets, rods and tubes.

Designated Tayloron PN, the material can be used at temperatures over 4000 F for short periods. Ad-

RUBBER in Design Engineering



Garlock offers dozens of different types of rubber, each carefully chosen and processed to meet your exacting needs . . . natural rubber with high tensile strength where real "rubber-like" properties are required . . . styrene butadiene rubber, the work horse of the industry—a low cost material for use where a good, rugged general purpose compound is required . . . neoprene rubber where good oil and abrasion resistance and aging characteristics are important. In addition, Garlock offers a wide range of nitrile and butyl compounds where their special properties are required. For more difficult applications Garlock offers a complete line of specialty rubbers from silicone for high and low temperature service to VITON* for extreme temperature and solvent resistance.

PROPERTIES	Non-Oil Resistant			Oil Resistant	
	Natural	SBR	Butyl	Nitrile	Neoprene
Tear Resistance	Excellent	Poor-fair	Good	Fair	Good
Abrasion Resistance	Excellent	Good	Good	Excellent	Excellent
Compression Set Resistance	Good	Good	Good	Very good	Good
Permeability to Gases	Fair	Fair	Excellent	Very good	Very good
Aging (Sunlight)	Poor	Poor	Excellent	Fair	Excellent
Aging (Oxidation)	Good	Good	Good	Fair	Good
Aging (Heat, max. temp. F)	200	250	300	250	250
Solvent Resistance (Aliphatic Hydrocarbons)	Very poor	Very poor	Poor	Good-Exc.	Fair
(Aromatic Hydrocarbons)	Very poor	Very poor	Poor	Fair-good	Poor
Oil Resistance (Low Aniline)	Very poor	Very poor	Very poor	Fair-Exc.	Fair
Oil Resistance (High Aniline)	Very poor	Very poor	Very poor	Fair-Exc.	Good
Gasoline Resistance (Aromatic)	Very poor	Very poor	Very poor	Fair-good	Fair
Gasoline Resistance (Non-aromatic)	Very poor	Very poor	Very poor	Good-Exc.	Good
Cold Resistance (Min. svc temp. F)	—65	—70	—65	—65	—50

This table gives you an idea of how some rubbers react to various conditions. In designing, consult your Garlock rubber specialist to achieve best application results.

Thoroughly tested to meet ASTM standards. Over twenty various tests are conducted on rubber materials before, during, and after manufacture to assure top performance. First, the rubber is carefully compounded and mixed exactly to specification. Then it is measured for durometer hardness, tensile strength, elongation . . . resistance to water, weather, temperature . . . many other vital characteristics. Scientific measurements like this, using ASTM, SAE-ASTM, and military standards—plus quality control during manufacture—assure you of the finest rubber parts available.

No two rubbers are alike. Each has its own individual strong points; each performs better under one set of conditions than another. In the design stage, call in your Garlock representative. He's a specialist in rubber parts and will assist you in selecting the proper material. Then, too, he may have several cost-saving ideas to suggest. You

GARLOCK

can reach him at the nearest of the 26 Garlock sales offices and warehouses throughout the U. S. and Canada. Or, write for Catalog AD-167, Garlock Inc., Palmyra, N. Y.

Canadian Div.: Garlock of Canada Ltd.
Plastics Div.: United States Gasket Co.

Order from the Garlock 2,000 . . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*Du Pont Trademark

For more information, turn to Reader Service card, circle No. 395

Chace THERMOSTATIC BIMETAL

Actuates Another Precision Product

RBM Electric Blanket Control

RBM Control Division
Essex Wire Corporation
Logansport, Indiana

Sleep, sleep, sleep . . . cozy, warm, comfortable. Room temperature and outside weather conditions have no effect on slumber when electric blanket temperature is governed by the RBM Blanket Control. Set it, then forget it . . . night after night . . . year in and year out. The RBM Electric Blanket Control assures comfortable, trouble-free sleeping conditions.

The thermostat control element is made up of three legs of thermostatic bimetal; the outside two are the deflection members and they are in compression. The center leg is in tension and is controlled by screw adjustment. This friction-free bimetal element is capable of closely holding temperature differential, even though it is of snap-action type.

This very successful and unique control is actuated by dependable Chace Thermostatic Bimetal. Chace is recognized the world over as the leader in the manufacture of thermostatic bimetal for snap-action elements. This fine Essex Wire product and many other controls lean heavily on the dependability of Chace Thermostatic Bimetal. This dependability is born of more than a third of a century of specializing in the manufacture of precision thermostatic bimetal; our only product. When you specify Chace, you specify dependability.

Send Now For Our New "Information Booklet"!

It contains many well illustrated pages of valuable design data and examples of successful applications of bimetal! More than 40 types of Chace Thermostatic Bimetal are available in coils, strips and completely fabricated elements of your design.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service card, circle No. 463

What's new IN MATERIALS

PROPERTIES OF TAYLORON PN

Specific Gravity	1.20
Flexual Strength, psi	
Lengthwise	13,000
Crosswise	12,500
Ther Cond, Btu/hr/sq ft/°F/in.	
150 F	0.81
200 F	0.71
250 F	0.77
Specific Heat, Btu/lb/°F	0.47

vantages include: lightweight, low thermal conductivity, excellent physical and thermal properties, good erosion resistance, high dielectric strength, good machinability, and high deflection under load.

KEY NO. 626

Hard-Soft Rubber Seals Are Easy to Install

One-piece rubber extrusions combining longitudinal sections of two different hardnesses are designed for sealing applications in the appliance and other industries. They are available from Geauga Industries, Middlefield, Ohio.

The soft part of the extrusion (60 Durometer) is for sealing and the hard part (90 Durometer) for mounting. The soft portion provides a suitable seal whether in a fixed or moving position. The hard portion is sufficiently flexible to fit curved openings, yet rigid enough so that it can be secured to mating surfaces with adhesives or fasteners.

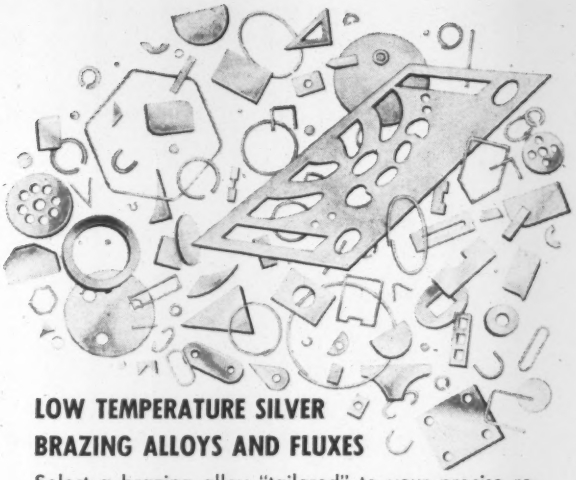
KEY NO. 627

Cutting-Grade Carbide Is Easy to Machine

A new cutting-grade carbide that is easy to machine has been introduced by Chromalloy Corp.'s Sintercast Div., 171 Western Hwy., West Nyack, N. Y.

Called Ferro-Tic J, the carbide can be turned, drilled, milled, tapped and filed in the annealed, as-received condition; heat treated to Rockwell C70, the material behaves like a solid carbide.

A fully sintered composite of ultra hard carbide particles dispersed in a



LOW TEMPERATURE SILVER BRAZING ALLOYS AND FLUXES

Select a brazing alloy "tailored" to your precise requirements from the complete line of Silvaloy Low Temperature silver brazing alloys and fluxes. Silvaloy bond is as strong or stronger than the metals joined... available in wire, coil, strip, plymetal or preformed shape most convenient and economical for your production procedure. • Silvaloy is used by the country's leading manufacturers to speed and simplify production, to assure highest quality work, at lowest cost. Write for literature.

AMERICAN PLATINUM & SILVER DIVISION
231 N. J. RAILROAD AVENUE • NEWARK, N. J.

LOOK TO AMERSIL FOR ALL HIGH PURITY FUSED QUARTZ REQUIREMENTS

Amersil manufactures and fabricates high purity fused quartz for ultraviolet transmission application, laboratory ware and production equipment. These products include standard apparatus, plain tubing in many intricate fabrications, crucibles, trays, cylindrical containers and piping in a full range of sizes up to 25" in diameter. Ingots and plates are available in general commercial quality as well as in special optical grades. Amersil engineers are also prepared to assist in developing fused quartz and silica equipment for special requirements.

AMERSIL QUARTZ DIVISION
685 RAMSEY AVENUE • HILLSIDE, N. J.

ENGELHARD PRECIOUS METALS RECOVERY SERVICE

Engelhard offers the most modern and complete facilities and technology for maximum precious metal recovery. Service is prompt, highest purchase prices are assured in refining of spent metal catalysts, jewelry filings, floor sweeps, sludges, other industrial residues. Values based on results of mutually acceptable assays; recovered precious metals purchased by Engelhard, credited to your drawing account or returned to customer. Contact local Engelhard Service Representative for assistance in recovery, separation, transportation problems.

REFINING DIVISION
429 DELANCEY STREET • NEWARK, N. J.

ENGELHARD
INDUSTRIES, INC.
EXECUTIVE OFFICES:
113 ASTOR STREET • NEWARK 2, NEW JERSEY

SALES OFFICES: CHICAGO • DALLAS • DETROIT • HOUSTON • LOS ANGELES • NEW YORK • ORLANDO • PROVIDENCE • SAN FRANCISCO • WASHINGTON, D. C.

* * *

Please send literature as indicated below, addressed to my attention:

☐ Silver Brazing Alloys and Fluxes ☐ Fused Quartz

☐ Precious Metals Recovery Service

NAME.....

TITLE.....

FIRM.....

STREET.....

CITY..... ZONE..... STATE.....

For more information, turn to Reader Service card, circle No. 417

LUBRICATION REPORT

(dry film coating)

Application: *Lock Part Pre-Assembly Lubrication.*
Problem: *Find a quicker, cleaner method of lasting lubrication.*
Solution: *dag ® Dispersion 154 — diluted in equal parts with denatured alcohol.*

RESULT: *CLEANER, MORE UNIFORM, LONGER-LASTING LUBRICATION ON LOCK PARTS*

Cam retainers and disc tumblers used in American Hardware Corporation's padlocks are 1/2 by 1/4 inch brass stampings. Because of their small size, this New Britain, Conn. manufacturer has found dipping to be the most efficient method of lubricating them. Acheson's 'dag' 154 proved to be ideal for this operation. Its alcohol carrier quickly evaporates, leaving a permanent film of graphite on the parts. This microscopically thin film is deposited uniformly, adheres tenaciously, and will not rub off during lock assembly. Since it does not attract dust and discourages oxidation and corrosion of the brass parts, 'dag' 154 provides a longer, smoother operating life for the locks.

For more information on the advantages of Acheson dry-film lubricants in product design, send for your copy of Bulletin No. 435. Write to Dept. ME-111.

ACHESON – First name in solid lubricants for fifty-four years.

ACHESON Colloids Company

PORT HURON, MICHIGAN

A division of Acheson Industries, Inc.

Sales offices in principal cities

Also Acheson Industries (Europe) Ltd. and affiliates. London, England

For more information, turn to Reader Service card, circle No. 476

What's new IN MATERIALS

high speed steel matrix, Ferro-Tic J is recommended for use as an insert in milling cutters and end mills, fly cutters, drills, broaches and form tools. The carbide can be used to cut ferrous as well as nonferrous and nonmetallic materials. Surface cutting speeds of 100 to 200 fpm on semi-hard alloys are possible without damaging tools made of the material.

Service life in cutting hardened steels compares favorably with that of conventional carbides, which can be shaped only by diamond grinding. Metal removal rates and tool life are said to be much higher than those of conventional high speed tool materials. **KEY NO. 628**

Noted briefly in our September issue.

Anti-Static Fluid for Plastic Surfaces

Static charges on the surface of plastics parts can be prevented by using a new chemical fluid now available in squeeze bottles and impregnated cloths from Daystrom, Inc., Weston Instruments Div., 614 Frelinghuysen Ave., Newark, N.J. It is called Statnul.

The developer says that unlike most anti-static solutions which rely on attracting moisture from the air for their conductive properties, Statnul provides a thin transparent film which is itself a good conductor of static charges. Parts treated with the fluid retain their anti-static properties even under extremely dry conditions.

Tests show the fluid has remained effective in sustained atmospheres of 2% RH long after other antistatic fluids have broken down.

KEY NO. 629

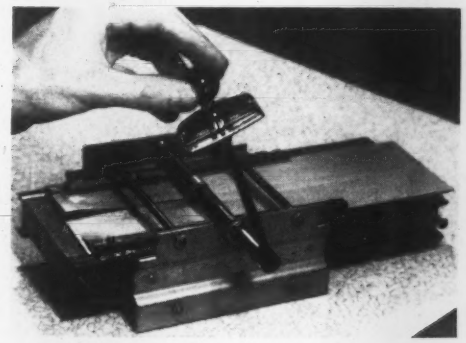
Surfacing Material for Decorative Uses

A vinyl surfacing material for decorative wear use over metal, wood, glass-reinforced polyester and other subsurfaces is available from Armstrong Cork Co., Industrial Div., Lancaster, Pa.

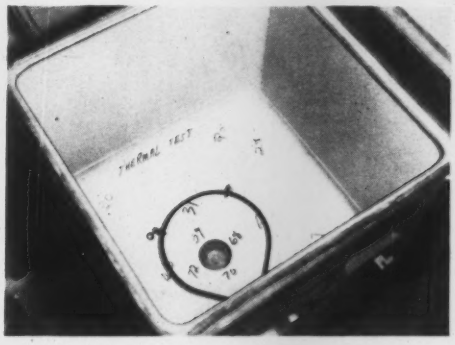
Called Decorlon, the material is

1 Production dishwashers get life tests by being cycled 24 hours a day for the equivalent of up to 15 years' normal use.

2 "Guillotine" test checks resistance of the plastisol lining to cutting. Sample panels can be tilted to various angles found in the tub.



3 Film adhesion of the vinyl to metal is measured on torque scale. Strip of coating is cut where unprimed, wrapped around shaft, and lever turned until primed area is reached.



4 Thermal degradation test used oversize Calrod® heater to assess ability of various thicknesses and formulations of plastisol to maintain color and physical properties intact.

M&T plastisol coating passes all tests for "lifetime" service in tough job

Among the severe applications for which vinyl plastisols are suited, one of the toughest is that of a dishwasher lining.

EXACTING SPECIFICATIONS: Consider the service conditions: scalding water, charged with strong detergents, impinging with high velocity against the lining. The lining has to be immune to all food stains. There's always the chance of dropped objects and broken glass — so the lining has to resist cutting injuries despite the tenderizing effect of heat. Vitally important, such a lining must be non aging. All told, to be completely satisfactory to the materials engineer, it must last the normal life of the machines.

PROVING PRIOR TO APPROVING: Torture tests checked every important physical and chemical property of the sprayed-on lining. Examples:

A unique "guillotine" tested the resistance to cutting. In production tubs, a shower of broken china and glass punished the lining under extreme conditions.

A vapor test gauged the vinyl-to-metal bond in a cabinet at 200°F and 100% relative humidity. If anything should cause loss of bond, blistering or breakdown, this should do it. It didn't. Film adhesion test, food stain and discoloration test, thermal degradation test — these too were applied. On top of all, production dishwashers were cycled round the clock for the equivalent of up to 15 years' use.

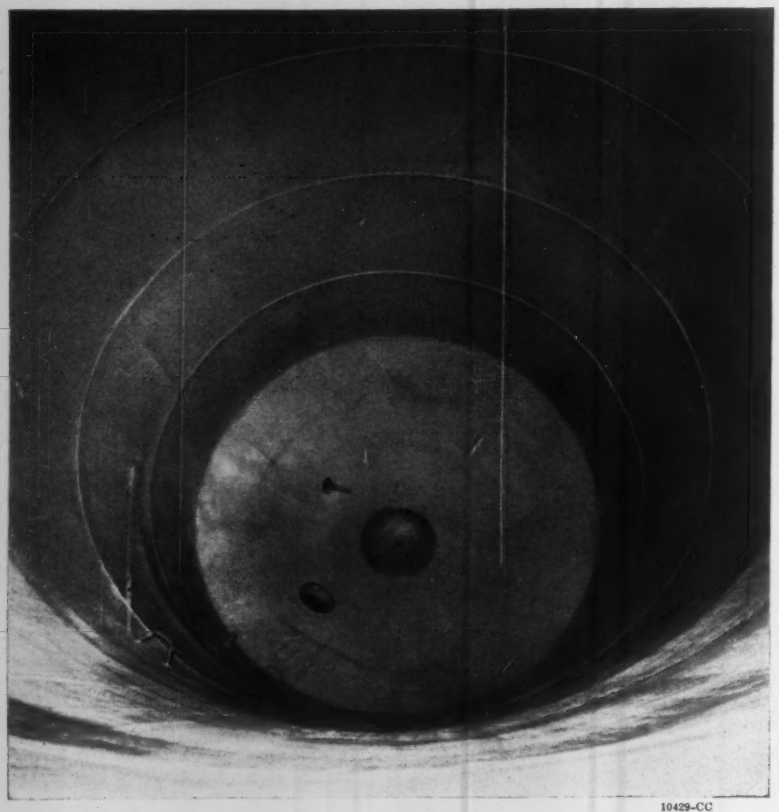
The Unichrome Plastisol from M & T satisfied all the conditions, and more. It helped insulate acoustically. It helped cut manufacturing costs.

When you require a heavy duty coating, it pays to investigate a Unichrome Plastisol. Various formulations are available to fit specific needs. Coatings provide chemical inertness of the vinyls, film build-up thick or thin as desired, resiliency, and ability to withstand abusive, abrasive service conditions. Send for more data, or for recommendations for your problem.

M&T coatings and finishes

METAL & THERMIT CORPORATION GENERAL OFFICES: RAHWAY, NEW JERSEY IN CANADA: M&T PRODUCTS OF CANADA LTD., HAMILTON, ONT.

For more information, turn to Reader Service card, circle No. 383



10429-CC

CEILCOTE CORROSION-PROOF COROLINE 505 TANK LININGS

COROLINE 505 LININGS . . . reinforced with Type "F" glass cloth are used for handling hot detergents. Other applications include: Chemical Storage tanks, processing tanks, pickling and plating tanks, pits and foundations. Tough, durable and long-lasting, COROLINE 505 provides proven resistance to most acids, alkalis and solvents . . . and, features good temperature resistance without permitting age hardening.

EASY APPLICATION IN SHOP OR FIELD: Applied in a "build-up" process, COROLINE 505 works easily with either trowel or brush. For steel or concrete surfaces, COROLINE 505 is generally reinforced with glass cloth. Application thicknesses vary from 3/32" to 3/16" depending on required operating conditions.

Send today for the CEILCOTE COROLINE BULLETIN . . . it contains all the facts.

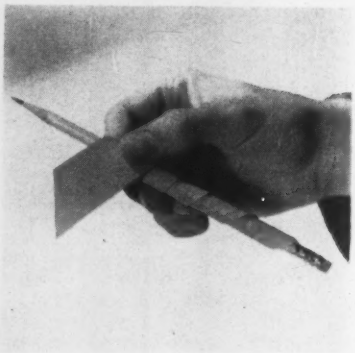
CEILCOTE COMBINES MINDS, METHODS AND MATERIALS . . . . . for the design and construction of CORROSION-PROOF equipment and installations for all industries.

CEILCOTE

THE CEILCOTE COMPANY, INC. • 4899 Ridge Road • CLEVELAND 9, OHIO

For more information, turn to Reader Service card, circle No. 493

What's new IN MATERIALS



***Flexibility** of new surfacing material is demonstrated by wrapping it around a pencil without cracking.*

supplied in 0.030 and 0.040-in. gages on a backing of felt. It is sold in three embossed textures—suede, knobby and striated—and in 20 colors.

The material is flexible, easily bonded with a variety of adhesives, durable, resistant to fading and most stains, dimensionally stable, and mold and mildew resistant. It has a flame-spread rating of 20 when tested in accordance with ASTM E84-59T.

Available in lengths up to 105 ft and widths up to 54 in., the surfacing material can be handled, cut and fitted the same as cloth, vinyl and other composition coverings.

Covering applications for the new material include bathroom scales, card tables, vending machines, elevator doors, laundry hampers, luggage, ceilings for airplanes, boat decks and door panels for trucks.

Noted briefly in our September issue.

KEY NO. 630

Durable Coated Fabrics for –100 to 400 F

Fabrics coated with a highly fluorinated synthetic rubber called Fluorel (M/DE, May '59, p 152) have ben introduced by the Irvington Div. of Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

According to the producer, the fabrics are inert to most fuels, solvents, acids and corrosive chemicals; are noninflammable; and resist oxi-

BOND FAILURES CAN BE PREVENTED!

Here's how to stop 13 of them...

Type of Failure	Solution
THERMOSETTING ADHESIVES	
• Cohesive failure	Check film with solvent used in adhesive. If solvent softens the adhesive film or becomes tacky, this indicates insufficient cure. Make sure bond line time and temperature is used.
• Adhesive failure from metal	If metal surface has a white, clean appearance, check cleaning technique.
• Adhesive failure from substrate other than metal	Try prime coat of diluted adhesive, also check compatibility.
• Cellular areas in adhesive line	Increase pressure and/or adhesive.
CONTACT ADHESIVES— room temperature setting	
• Tacky film	If film should dry hard but remains tacky, the cause may be entrapped solvent or migration of plasticizer from one substrate.
• Shiny areas	Poor contact, insufficient pressure or insufficient amount of cement.
• No bond	If heat reactivated type, adhesive was too cool at time of assembly or poor compatibility.
• Failure in adhesive from metal	Improper cleaning.
• Failure from substrate other than metal	Incompatible or unclean surfaces.
HOT MELT	
• No bond	Incompatibility, adhesive too cool at time of assembly. Parts too cool at time of application of adhesive.
EPOXY BASE ADHESIVES AND CASTING COMPOUNDS	
• High exotherm	Mix lower volume and pour mixed material into shallow tray. Cool base and activator before mixing or use Metermixing equipment.
• Tacky film or casting	Improper base activator ratio, improper mixing of base and activator, improper cure. Check bond line temperature.
• Flexible casting or film of rigid adhesive or casting compound	Improper mixing of base and activator, improper base and activator, improper cure. Check bond line temperature.

Bond failures can be prevented! Raybestos-Manhattan's adhesive experts also have solutions to less common causes of bond failures . . . based on more than 20 years' experience in the production of bonded assemblies and the manufacture of adhesives, coatings and sealers. Why not call on them today for the answers to your adhesive problems—no cost or obligation, naturally.

R/M Bulletin No. 700 is packed with helpful technical information on Ray-BOND adhesives. Write for your free copy now.

RAYBESTOS-MANHATTAN, INC.

ADHESIVES DEPARTMENT, Bridgeport, Conn. • Chicago 31 • Detroit 2 • Cleveland 16 • Los Angeles 58

R M

For more information, turn to Reader Service card, circle No. 409

NANMAC CORPORATION

is proud to introduce the . . .

"PLASTIC THERMOCOUPLE"

MODEL-P

The body of the Model "P" thermocouple can be fabricated from any plastic, plastic-mineral composites, non-metal, alloy, or special proprietary material. Thus surface or in-wall temperatures of a wide variety of materials can be measured accurately without disturbing the normal heat distribution pattern caused by differences in thermal properties. Examples of materials successfully used in the Model "P" include: plexiglass, asbestos phenolics, graphite, copper, molybdenum and special proprietary plastics.

FEATURES

- √ Response time—less than 10 microseconds to transient temperatures.
- √ Thermal junction maintained even during erosion.
- √ Temperature range from —320° F to over 5000° F.
- √ Pressure range to over 5000 PSL.
- √ Two-dimensional thermal junction for accurate location of point of measurement.
- √ Thermocouple constructed of flat ribbon wires and mica insulation.

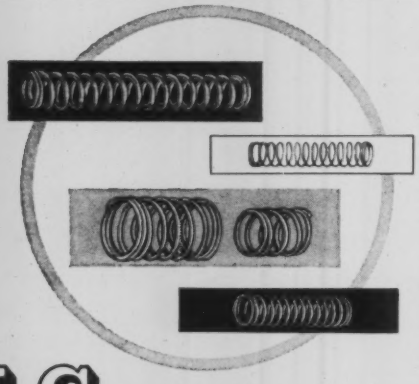
NANMAC CORPORATION

P.O. BOX 8 INDIAN HEAD, MARYLAND

NAN-MAC THERMOCOUPLES

WRITE FOR BULLETIN TB161

For more information, turn to Reader Service card, circle No. 414



MICRO-PROCESSED FOR **EXTRA** RELIABILITY!

Micro-processed I-S beryllium copper compression springs, being non-magnetic and corrosion resistant, and having good electrical conductivity, are exceptionally well suited for critical applications. Undesirable internal stresses are removed during heat treatment resulting in better current carrying capacity, lower drift and higher endurance life. The exclusive process by which I-S Micro-processed springs are manufactured make it possible to fulfill the most exacting specifications in all respects. Unusually close tolerances are held on diameters ranging from .020" to 1.00" ID. Laboratory certified beryllium copper wire in standard B & S gages from .0025" to .072" with a tensile strength of over 200,000 psi is used in producing I-S Micro-processed springs. Close quality control is maintained to insure correct spring rate and load requirements.

I-S Beryllium Copper Springs

Call or write for I-S catalog including data on:

- COMPRESSION SPRINGS
- FLAT SPRINGS
- STRIP SPRINGS
- CONTACT RINGS
- CONTACT STRIPS
- SCREW MACHINE PRODUCTS

FOR FURTHER INFORMATION SEE OUR CATALOG IN SWEET'S

INSTRUMENT SPECIALTIES CO • INC

224 Bergen Blvd.
Little Falls, N. J.

Telephone: CLifford 6-3500

For more information, turn to Reader Service card, circle No. 396

What's new IN MATERIALS

dation, ozone and weathering. The coated fabrics can be used continuously at 400 F without change in properties and do not crack at temperatures down to –100 F.

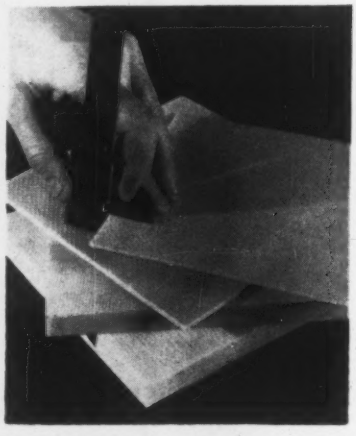
Available with either glass or Dacron as a base material, the coated fabrics are strong and abrasion resistant. Tensile strength ranges from 140 to 480 psi and bursting strength from 310 to 650 psi, depending on the base fabric.

Potential applications for these coated fabrics include gaskets, diaphragms, flexible boots and bellows, hoses, high and low temperature flexible ducting, and blast deflection curtains. KEY NO. 631

Silicone Plate for Class 360 F Uses

An economy-grade silicone plastics plate for general applications requiring Class 360 F (formerly Class H) temperatures is available from Micarta Div., Westinghouse Electric Corp., Hampton, S. C. Possible applications include transformers, barriers, rotating apparatus, coil washers, slot wedges, slot filler strips, coil end turns, spacers and hangers.

Called H-9758, the plastics plate is supplied in four standard sizes from 36 by 36 in. to 48 by 96 in. Cost



***Measuring** thickness of new silicone plate that is supplied in thicknesses from 1/32 to 2 in.*

SICON® *the original silicone base heat resistant finish, delivers dependable*

pROTECTION AGAINST HEAT

On the **INSIDE** and **OUTSIDE** of High Temperature Combustion Tube Furnaces

Only the finest kind of heat resistant finish satisfies engineers of the Hevi-Duty Electric Company, Milwaukee. The Hevi-Duty Combustion Tube Furnace shown here handles very high temperatures. The sheet steel furnace shell is protected *both on the inside and outside* by SICON in an attractive metallic green, capable of withstanding surface temperatures approaching the 1000°F. range. The inside application prevents rust from forming due to condensation which forms when furnace is initially started. While actual heat loss is minimal, due to highly efficient insulating brick, and by asbestos ends, Hevi-Duty knows from extensive experience that SICON will hold its original color indefinitely, will not chip, peel or powder under actual service use. This marked ability of Sicon to retain its film integrity and color under sustained heat, has made it preferred for scores of other products—manifolds, space heaters, incinerators, even missiles. Send details of your heat problems or fill out and mail coupon today.

Sicon® *Hi-Temperature finish*

by **MIDLAND**
INDUSTRIAL FINISHES CO.
WAUKEGAN, ILLINOIS
Enamels—Synthetics—Lacquers—Varnishes

MIDLAND INDUSTRIAL FINISHES COMPANY
Waukegan, Illinois

Please send copy of latest SICON brochure containing complete heat resistant and chemical characteristics and specification details. Dept. K-1.

Firm_____
Name_____
Title_____
Address_____
City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 397

Graphite Specialties Can Solve Difficult Problems

Custom grades of graphite are regularly formulated by Graphite Specialties Corp., and furnished in extruded, molded and machined shapes to close tolerances to meet a wide range of difficult applications . . . *OR* GSC may be able to provide one of their many existing formulations to meet your requirements.

GRAPH-I-TITE: A collection of unique properties in one material, so valuable for such a wide diversity of uses, that GRAPH-I-TITE is furnished in two grades in standard sizes of rod and tube, as well as machined shapes. GRAPH-I-TITE possesses uniform high density . . . low permeability . . . immunity to thermal shock . . . resistance to corrosion at extremely elevated temperatures . . . and is not wetted by molten metals.

CARBO-TITE: Similar to "Graph-i-tite" except a carbon, rather than graphite base, and Carbo-tite is as hard as glass, and features a relatively *low* rate of thermal conductivity.

NUCLEAR: Purity grades to specified density for lowest neutron-capture cross section; highest scattering cross section for moderator, fuel elements, structural parts and piping and related equipment.

METALLURGICAL: Custom shapes and grades of graphite for special molds, dies, crucibles, boats, etc., for the chlorination of metals and other difficult applications.

MISSILES & ROCKETS: Recent developments make special grades of graphite particularly promising for nose cones, rocket nozzles and similar high temperature, high erosion applications.

MECHANICAL: Grades available with specified properties including temperature resistance to 5700°F., hardness to 5 + Mohs for bearings, seal rings, seats, etc.

FURNACES: In addtion to graphite components for resistance and induction furnaces, Graphite Specialties Corp. designs, manufactures and installs compete ultra-high temperature furnaces for heating requirements as high as 5700°F.

CHLORINE HEATERS: Special furnace development has led naturally to manufacture of what is believed to be the first practical type of chlorine heater for any temperature requirement to 5700°F.

Write to GRAPHITE SPECIALTIES CORP., Blank & Walmore Rds., R.R. 2, Sanborn, New York

For more information, circle No. 364

What's new IN MATERIALS

is approximately 20% under standard grades.

The silicone plate is said to have excellent electrical properties and high impact strength; mechanical and electrical properties are only slightly under those of standard silicone laminates. Impact strength is 20 ft-lb per in. for ⅛-in. thick plate, dielectric constant is 4.8 to 4.9 at 1 mc, and volume resistivity is 10^7 megohm-cm. KEY NO. 632

Nonwoven Acrylic Used for Filtering

A nonwoven acrylic fabric for filtering applications has been introduced by Rogers Corp., Rogers, Conn. The papermaking techniques used to produce the material are said to permit a greater degree of control over fiber matting and over the bonding of fibers than do other basic methods of making nonwoven fabrics.

Called Duroid 2155, the material is a finely webbed mesh of acrylic fibers loosely bonded by an acrylic resin. The material is presently being used as a filter in a deionizing unit that processes up to 300 gal of water per hour with an ionic purity equal to that of multiple distilled water. KEY NO. 633

Beryllium Copper Resists Salt Water

A new beryllium copper alloy called 16C has been introduced by Beryllium Corp., Reading, Pa. It is presently being fabricated into castings and couplings for use in a new type of underwater telephone cable system.

The new alloy, developed jointly by Beryllium Corp. and Bell Telephone Laboratories, is highly resistant to salt water corrosion. According to the developer, the alloy's

PROPERTIES OF 16C ALLOY

Yield Strength (0.2% offset), psi	140,000
Tensile Strength, psi	160,000
Elongation (in 1.4 in.), %	2.5
Rockwell Hardness	C36

YOU PICK THE ALLOYS

AIR MELTED

Low Alloy Series, including: 4100, 4300, 8600

400 Series Stainless, including: 410, 416, 420, 431, 440

300 Series Stainless, including: 302, 303, 304, 310, 316, 347

PH Alloys, 17-4, AM355

Hastelloys

Cobalt-base Alloys, HS3, HS6, HS30, HS151, WI-52, X-40, AMS-5382, AMS-5385

VACUUM MELTED

713C
Udimet 700
R-235D
Nicrotung
SM302
DCM
Oxy-Free Copper

—or any other alloy similar to these—

WE'LL CAST THEM

singly, or on a production basis . . . and *heat treat* them to give you characteristics in *excess* of specifications.

A complete INVESTMENT CASTING Service

PRECISION INVESTMENT & CERAMIC SHELL CASTING. EXPERTS IN HIGH TEMPERATURE AND HEAT TREATED STEELS. LARGEST CASTERS OF COBALT AND NICKEL ALLOYS IN THE WEST.

PRECISION CASTPARTS CORPORATION
4602 S.E. Harney Drive
Portland 6, Oregon
PRospect 5-4391

Represented nationally by:

District Sales Corp., ANgelus 3-2149
Los Angeles 22, California

ESCO, DUdley 8-5901
Denver 7, Colorado

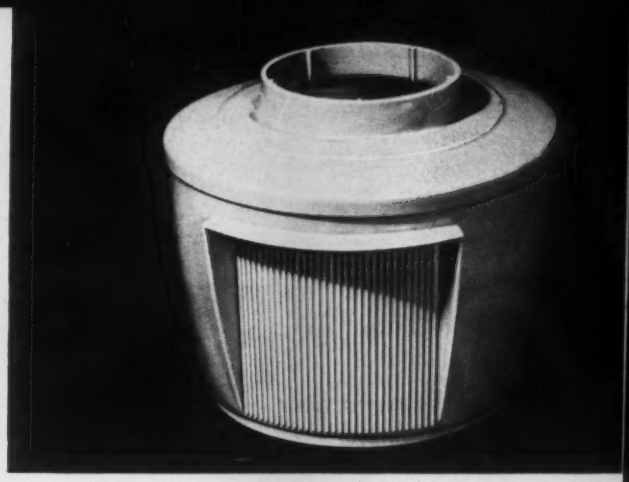
ESCO, ORegon 9-3240
New York 17, New York

ESCO, Hickory 6-2210
Danville, Illinois

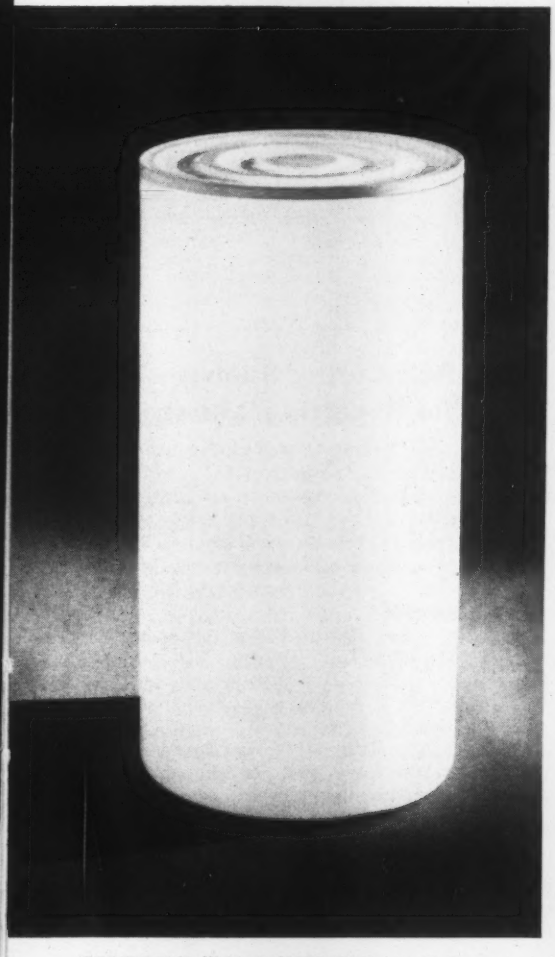
John Lobb, MOhawk 4-0740
Bellaire 101, Texas

For more information, circle No. 429

INSTRUMENT HOUSING—Made of MARLEX, it's lighter and more durable, resists cracking and warping . . . for "Plug-Scope," spark plug tester manufactured for Champion Spark Plug Company by Heyer Industries, Incorporated.



VAPORIZER HOUSING—Attractively styled for a popular Hankscraft product, this component has molded-in color and texture . . . won't warp or crack with boiling temperatures.



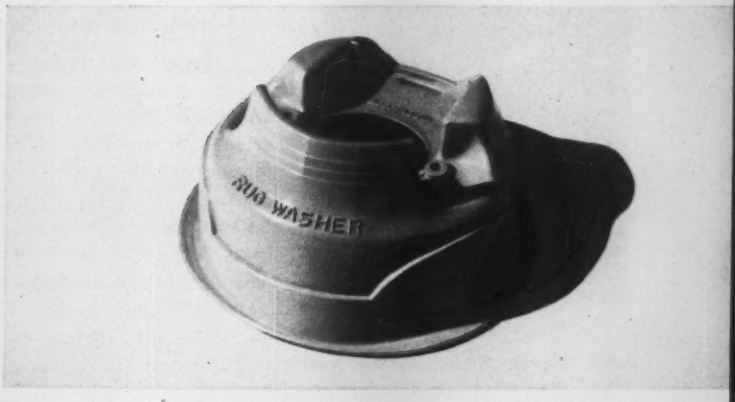
BRINE TANK—Welded of MARLEX sheet with Thermoformed top and bottom . . . this Premier Plastics water softener tank will never corrode or scale up . . . gives longer and improved service at low cost.

MARLEX* components for economical "quality up-grading"

To improve product performance while keeping production costs down, more and more manufacturers rely on components molded or formed from MARLEX high density plastics. A representative selection is shown here.

MARLEX plastics (high density polyethylenes and ethylene copolymers) are lightweight, tough, and virtually indestructible . . . resistant to acids, alkalies, greases, fungi, and corrosion. They possess high dielectric strength and a wide usable temperature range (−180°F to 250°F). Components of MARLEX can be molded, thermoformed, extruded, welded, machined, printed upon, and endowed with integral color.

*MARLEX is a trademark for Phillips family of olefin polymers.



RUG WASHER HOUSING—Precisely molded, this rugged Electrolux part of MARLEX is lightweight, tough, and non-corroding . . . will not chip, dent, bend or warp.

For more information, see your plastic fabricator . . . or contact us.

PHILLIPS CHEMICAL COMPANY

Bartlesville, Oklahoma

A subsidiary of Phillips Petroleum Company

PHILLIPS 66 MARLEX PLASTICS

For more information, turn to Reader Service card, circle No. 345

25 years of progress in tiny parts

☐ REDUCE COSTS
☐ SIMPLIFY ASSEMBLY
☐ IMPROVE APPEARANCE with

DIE CAST ZINC ALLOY & MOLDED NYLON

GRC FASTENERS

DIE CAST ZINC ALLOY
Wing Nuts
Cap Nuts
Thumb Nuts

Round Head
THUMB NUTS

Open End
Closed End

GRC's exclusive wide grip; generous width tops have deep fluted edges for firm, comfortable grip. Corrosion resistant, rustproof. Smart design for added sales appeal.

Head Diameters: ½" thru 1¼"
Thread Sizes: #4 to 7/16"

• Uniformly accurate • Wide range of
• High in quality stock styles, types,
• Low in cost sizes and threads

Produced in one high speed automatic operation, GRC's exclusive methods assure uniformity, smooth, rustproof & corrosion resistant surfaces and the lowest possible cost. New kinds of fasteners never before available . . . modifications in stock fasteners for specialized use . . . infinite variety in styles, types and sizes, have been made possible by GRC's special automatic die casting and molding machines.

Write, wire, phone RIGHT NOW for samples, prices, your copy of GRC's NEW DETAILED INDUSTRIAL FASTENER CATALOG

Thumb & Wing Screws
MOLDED NYLON
Screws
Hex Nuts
Washers
Screw Insulators

World's Foremost Producer of Small Die Castings

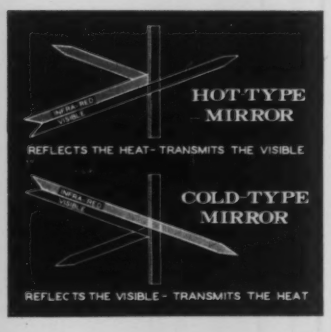
GRIES

GRIES REPRODUCER CORP.
153 Beechwood Ave., New Rochelle, N. Y., NEw Rochelle 3-8600

For more information, turn to Reader Service card, circle No. 447

ADVERTISEMENT

HOT AND COLD MIRRORS



Dichroic coatings reflect infrared and transmit visible wave lengths; or vice versa

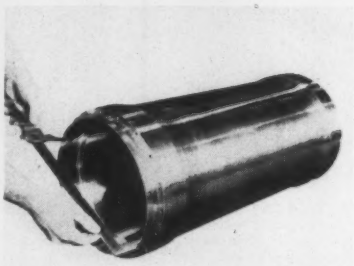
Hot type or cold type, whichever serves your purposes, Liberty Mirror can supply front-surface or back-surface mirrors with Hi-Efficiency dichroic coatings applied by vacuum-deposition. They are highly durable and easily cleaned with non-abrasive cleaners. The coatings themselves will withstand ambient temperatures of minus 60°F. and plus 600°F.

Other vacuum-deposited coatings of aluminum, chrome or gold are used to make first-surface mirrors, neutral filters, transparent mirrors, high-efficiency beam splitters and laminated mirrors.

Applied to glass, optical parts, metal, epoxy or plastic, the coatings are used in such varied products as scientific and optical instruments, toys, cameras, pin setters, wheel-aligning equipment, aircraft and missiles. If you have a potential application or new use, Liberty Mirror engineers will help you solve your problems. Technical data sheets available on all coatings. Write L-O-F, Liberty Mirror Division, 23111 Libbey-Owens-Ford Building, Toledo 1, Ohio.

For more information, turn to Reader Service card, circle No. 372

What's new IN MATERIALS



Cylinder housing *of beryllium copper alloy will be used in a new underwater telephone cable system that will link the United States and Europe.*

strength and hardness permit it to withstand continuous pressures of 12,000 psi when fabricated into thin-walled parts. **KEY NO. 634**

Noted briefly in our October issue.

Self-Curing Rubber for Repairing, Lining

A two-part, self-curing rubber compound is designed for a variety of applications such as repairing hose, conveyor belting and other rubber products; making thick or thin gaskets in place; and lining chutes, tanks, pumps and other machinery.

Called Devcon R, the compound is available from Devcon Corp., Danvers, Mass. It is supplied as a putty, called R-A, and as a liquid, called R-B.

According to the developer, both grades have good adhesion to iron, steel, aluminum, wood, natural and synthetic rubbers, canvas, glass and some plastics. The cured compound does not change shape under pressure, and it has good tensile and tear strengths, and good abrasion resistance. It also has good low

PROPERTIES OF DEVCON R[a]

Ten Str, psi	106
Elong, %	100
Tear Str, lb/in.	16
Compr Set (20 hr at 150 F), %	48
Durometer Hardness	A70

[a]Specimens cured 24 hr at 70 F.

SILICOLOGY

Studies in Silicones

HOW THESE TIME-TESTED MATERIALS CAN WORK FOR YOU

Turn on the heat—
Silicone-based coatings can take it!

If you were to list the outstanding characteristics of silicone resins, chances are that "heat resistance" would rate near the top.

Paint manufacturers who formulate high-temperature coatings have long been aware of this important property and are turning more and more to silicone resins as a base for their products. These range all the way from high-temperature enamels for electrical appliances to special paints used on rockets and missiles, jet aircraft engines, and other advanced space vehicles.

In many cases, the choice in silicone resins inevitably leads to one made by UNION CARBIDE, not only because of their unmatched reliability and uniformity, but because each has been scientifically designed to meet a specific paint requirement.

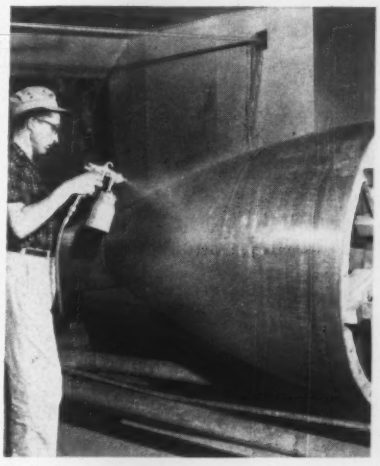
LOW-TEMPERATURE CURE

Take UNION CARBIDE R-630, for instance, a new low-temperature curing resin which has been widely adopted by the paint industry as a base for appliance finishes and for paints on engines, motors, generators and other high-temperature electrical equipment. Enamels based on R-630 are free from many of the handling problems inherent in the use of other silicone varnishes and may be applied over any metallic surface by spraying, flow coating, brushing, or dipping. Lighter in weight, more flexible and less expensive than ceramic coatings, it can be blended with acrylic enamels to give them improved thermal stability and resistance to weathering.

The color range is virtually limitless, and high-temperature enamels based on R-630 have outstanding durability, salt spray resistance and water-repellency. In addition, paints based on R-630 can be packaged in aerosol sprays for consumer use on home ovens, stoves and radiators.

LOW-COST ALUMINUM PAINTS

To combine economy with performance, many large-scale users of paints are adopting UNION CARBIDE R-64, a silicone resin which can be cold-blended easily with many organic resins as vehicles for aluminum paints. With only 7 to 11 per cent by weight of resin needed in the formulation, aluminum paints of this type give outstanding protection in the 500-1200 deg. F. range and still retain their silvery appearance under these high-temperature conditions.



Silicone base aluminum paint, which provides surface protection up to 1700 deg. F., is sprayed on rocket engine jig at Rocketdyne plant of North American Aviation. The paint, known as CI "Extra High," is made by Chem Industrial Co., Cleveland, O., and is based on silicone resins made by Union Carbide.

Applied by brush or spray, such paints are used as protective coatings for aircraft engines and exhaust stacks, truck and engine manifolds and mufflers, furnaces, ovens, stove and heater doors, and metal smoke stacks. Heat and flame-resistant protective clothing can also be fabricated from asbestos cloth coated with aluminum paints based on R-64 organic blends.

MAXIMUM THERMAL STABILITY

If factors of heat, weather and corrosion constitute a major problem for you, take a look at still another UNION CARBIDE product, R-611. Developed specifically as a resin vehicle for metallic and non-metallic pigmented high-temperature enamels, it provides the *ultimate* in thermal stability and offers far greater heat, weather and corrosion resistance than organic paints. Typical applications are in paints for ovens, incinerators, high-temperature electrical appliances, lamp shields and reflectors, smoke stacks, piping, engines, motors, generators and high-temperature processing equipment such as are found in many chemical and metallurgical industries.

R-611 based paints can also be packaged in aerosol sprays for consumer use on home ovens, stoves and radiators.

LASTING QUALITY

Silicone-based coatings mean savings because they provide protection for longer periods of time. If you have a coating performance problem, look to UNION CARBIDE Silicones for your answer. Your Silicones Man is at your service. Behind him is not only his know-how, but the vast experience and research of Union Carbide Corporation in virtually every field of industry. For information and help, fill in the attached coupon and mail it today.

UNION CARBIDE

SILICONES

UNION CARBIDE is a registered trade mark of Union Carbide Corporation.

Silicones Division
Union Carbide Corporation
Dept. JM-6101, 30-20 Thomson Avenue,
Long Island City 1, N. Y.

In Canada: **Union Carbide Canada Ltd., Bakelite Division, Toronto 12.**

Please send me data on resins_____

NAME _____

TITLE _____

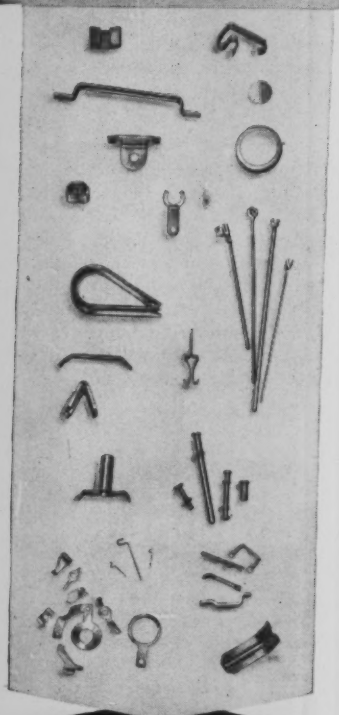
COMPANY _____

ADDRESS _____

CITY _____ ZONE ____ STATE ____

For more information, turn to Reader Service card, circle No. 425

PRECISION WIRE FORMS



Send a sample or blue print for estimates.

Art Wire specializes in wire forms designed for today's automatic production lines . . . manufactured with the precision and uniformity that assure the economy of an uninterrupted work flow. Reduced down-time, and the lower costs made possible by Art Wire's modern production methods mean greater savings to you, and greater profit in your operations.

ART WIRE AND STAMPING CO.
13 Boyden Place, Newark 2, N. J.

For more information, circle No. 377

What's new IN MATERIALS

temperature flexibility and good oil and chemical resistance. Composition has not been disclosed. KEY NO. 635

Chromate Coating Protects Aluminum

A new chromate conversion coating is said to produce a highly corrosion resistant surface on aluminum. Introduced by MacDermid Inc., Waterbury 20, Conn., the coating is called Macro Alum No. 5.

According to the producer, the coating gives corrosion protection equal to or better than that obtained with anodizing at much lower installation and operating costs. The coating is approved under specification MIL-C-5541 for use as a paint base and as a corrosion preventive film for aluminum and aluminum alloys.

The coating can be used for decotive and protective purposes and as a base for paint. Treated surfaces have low electrical resistance. Extremely large parts, strip and parts with deep recesses can be processed easily with the coating. Color of the coating can be varied from brass to bronze without loss in original brightness. KEY NO. 636

Polypropylenes Have Good Impact Strength

Four new polypropylene resins have been introduced recently by Enjay Chemical Co., Div. of Humble Oil & Refining Co., 15 W. 51st St., New York 19. Sold under the name Escon, they have good impact strength and excellent processability.

205 is a general purpose grade combining high flow with good impact strength.

215 has the same properties and processing characteristics as 205, but is formulated using only food-grade additives.

223 is a general purpose grade formulated for applications requiring good resistance to low temperature impact.

233 differs from 223 only in that it contains food-grade additives.

In addition to the four impact

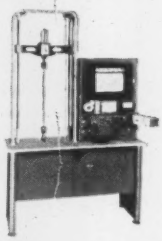
TENSILE TESTING IS EASIER WHEN THE UPPER CLAMP MOVES!

Scott Model CRE Constant-Rate-of-Extension Tester combines the precision of electronic weighing with exclusive "user-designed" features — it's today's *simplest, most convenient, most versatile* tensile tester for laboratory or production testing.

Upward Moving Crosshead offers great *operating convenience* — enables seated operator to observe specimen behavior at *eye-level,* even when testing high elongation materials. Crosshead pulls top holding clamp away from lower fixed clamp at a preselected constant rate. Resultant force is measured electronically and converted into easily understood stress-strain information on a strip chart.

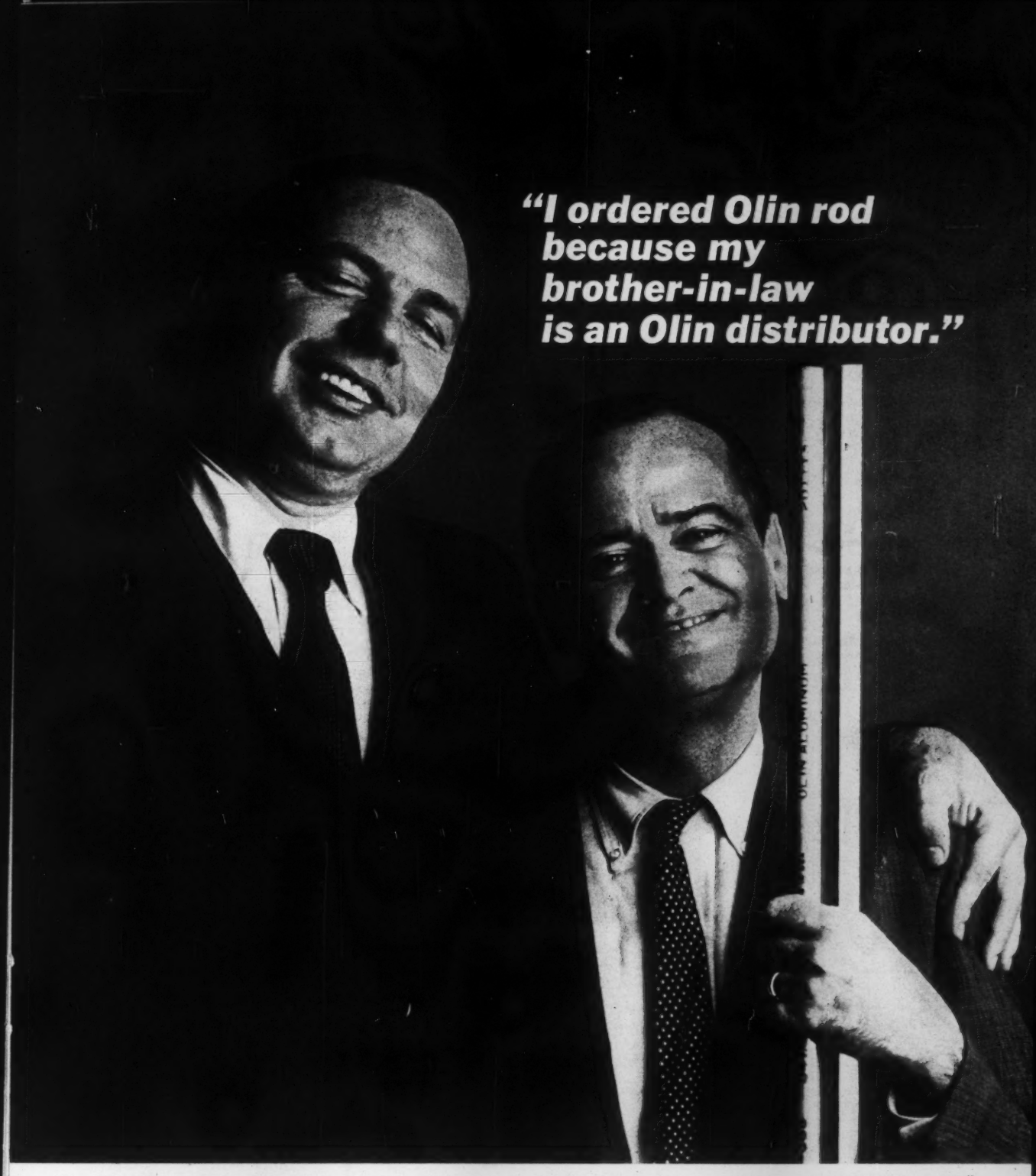
Testing Simplicity. Finger-tip controls provide wide range of crosshead speeds, complete and instant crosshead start-stop control, and a wide range of test capacities. Operator can obtain accurate test data easier and faster . . . and make more tests per day!

Versatile Model CRE uses *all* Scott interchangeable clamps and fixtures to meet ASTM, ISO and Industry Test Methods. Special accessories such as "pipping control" (for elastomeric testing), specimen dimension compensator, "time-to-break" signal, and others help you meet industry requirements on a simple, economical basis. Write for CRE Brochure. Scott Testers, Inc., 65 Blackstone St., Providence, R. I. Tel. DExter 1-5650 (Area Code 401).



SCOTT TESTERS
THE SURE TEST... SCOTT!

For more information, circle No. 352



"Sentiment? Not a bit! Common sense. Smartest thing George ever did was to tie in with Olin. Smartest thing I ever did was to use Olin Aluminum rod and bar. I had an Olin consultant take a look at my screw machine operation. He showed me how Olin's exclusive cold processed aluminum rod would give me a better end product because of its sound structure and excellent finishing qualities—and up my production rate per hour. Actually, my brother-in-law recommended the Olin consultant. How many brothers-in-law have come up with ideas that can save a guy up to 30% on finished parts?" **Nobody thinks in aluminum better than Olin. Want to talk to our consultants? Call your local Olin Aluminum Sales Office or Distributor.**

Olin
ALUMINUM
400 PARK AVE., NEW YORK 22, NEW YORK

For more information, turn to Reader Service card, circle No. 449

INSULATED WIRE
that will withstand 3000°F

- Available in outside diameters of .025 to .313.
- One or more wires insulated from metallic sheath by a ceramic oxide.
- AerOPak can be bent and weldments performed without loss of insulation.
- Available in a variety of metal sheath materials, insulations and wires.

Ask for Bulletin 4.

VSMF THE MICROFILM CATALOG FILE

AER O PAK
Electrical Conductors
Thermocouple Wire
Miniature
Heating Elements

AER O PAK
Thermocouples made to your specifications
Send for Bulletin 3.8A

Aero Research
INSTRUMENT COMPANY, INC.

DEPT. MDE, 315 NORTH ABERDEEN • CHICAGO 7, ILLINOIS
Sales Representatives throughout the United States and Canada
For more information, turn to Reader Service card, circle No. 442

LIKE JEWELS
. . . they radiate quality

It's true!

That's because Du-Co ceramics are produced by experienced personnel, equipped with modern machines and engineering methods to make quality a reality! Starting with the raw materials thru exhaustive test patterns and firing techniques, the indelible stamp of perfection glistens from each dimensionally-accurate part!

You see it . . . feel it . . . when it's Du-Co!

Send for the new Du-Co catalog which shows how Quality is produced in technical ceramics . . . but on your letterhead—please!

DU-CO steatite and technical ceramics

"Proud to Serve You"

DU-CO CERAMICS CO.
202 Main Street Saxonburg, Pa.

For more information, turn to Reader Service card, circle No. 339

What's new IN MATERIALS

PROPERTIES OF POLYPROPYLENE RESINS[a]

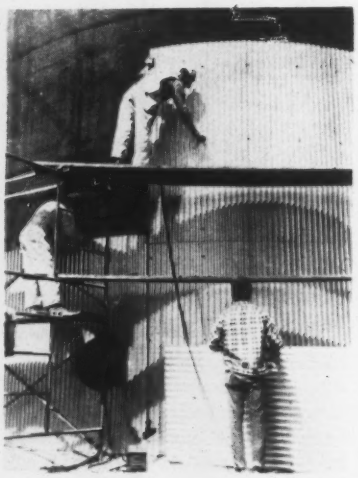
Grade ➡	205	223
Melt Index, gm/10 min	5.0	1.0
Impact Str (Izod unnotched), ft-lb/in.		
—40 F	8	17
—20 F	8	22
0 F	9	25
30 F	16	No break
72 F	50	No break

[a]Tests performed on injection molded specimens.

grades, Enjay says that its Escon polypropylene line now includes a wide range of pearlescent shades. The pearlescent colored polypropylenes are expected to be used for jewelry boxes, novelties, electric razor housings, combs, brush handles, costume jewelry and bathroom hardware. **KEY NO. 637**

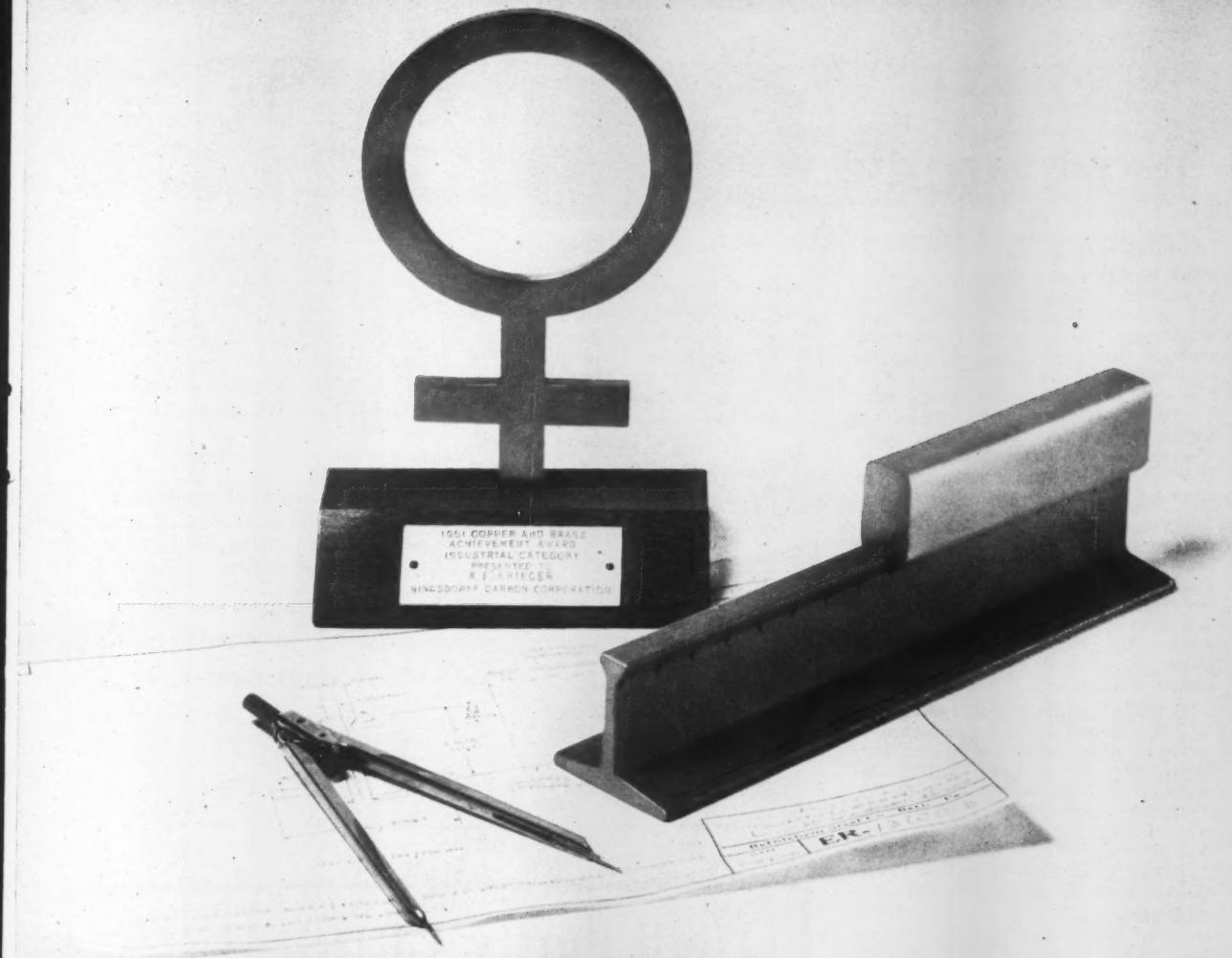
Metal-Faced Insulation Is Weather Resistant

A new thermal insulating system combines a highly efficient silica insulating material with a diamond-rib aluminum facing sheet. Developed by Johns-Manville, Insulation Div., 22 E. 40th St., New York 16



***Workmen** apply new metal-faced thermal insulation on an outdoor storage tank.*

For more information circle No. 406 ➤



Bethlehem special bar section helps capture design award for copper-headed steel conductor rail

This year's top industrial award in the annual Copper and Brass Research Association achievement competition went to this copper-headed steel conductor rail. Manufactured by Ringsdorff Carbon Corporation, East McKeesport, Pa., the rail combines the conductivity of copper with the strength of steel. The result is a compact, low-maintenance product, ideal for use on fixed-track, materials-handling equipment.

Steel

for Strength . . . Economy . . . Versatility

STEEL "T" SECTION COPPERHEADED BY UNIQUE PROCESS

To produce the rail, Ringsdorff draws the two components—the extruded-copper "head" and the hot-rolled Bethlehem carbon steel "T" section—through a die which compresses the copper flanges around the bulbed end of the tee, as well as around the diamond-shaped "ribs" rolled into each side of the steel. These ribs are an essential feature of the hot-rolled bar, as they serve to unify the thermal expansion of the two metals: since the copper head is free to move along the steel tee only between two adjacent ribs, the effect of their different expansion rates cannot become cumulative along the 30-ft length of the rail.

GET DESIGN FREEDOM WITH SPECIAL BAR SECTIONS

Let Bethlehem quote on the shape you need in a hot-rolled steel bar. We've rolled hundreds of different carbon and alloy sections, each one to a customer's individual specifications. Thousands more "undiscovered" sections are practical. Our design experts are at your service—just call any Bethlehem office.

BETHLEHEM STEEL COMPANY, Bethlehem, Pa. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Covers chemistry, raw materials and industrial applications . . .

CERAMICS

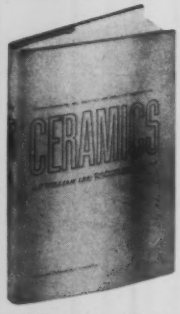
by P. WILLIAM LEE
Head, Porcelain Research Department, The Dentists' Supply Company

HERE IS THE FIRST WORK to present a comprehensive survey of the entire field of ceramics within a single convenient volume. The book reviews the applications of ceramic materials in industry, and covers their history, raw materials and basic chemistry. It also covers specialized topics such as the use of ceramics in electronics, dentistry, high temperature refractories, and low temperature enamels.

SPECIAL ATTENTION IS GIVEN to new and recent developments in this important field. Many new ceramic materials have been developed which have unique engineering properties for specialized fields of use. The author discusses a number of these materials as well as the new fabricating techniques.

THIS BOOK WILL PROVE HELPFUL to both technical and non-technical readers who want an all-around knowledge of ceramics. Ceramic industries of all kinds (art work, bricks, china and enamel ware, etc.) and the electronics, glass, structural products and steel industries will find this a compact guide and reference to ceramics as an industrial material.

CONTENTS:
Introduction—Principal Raw Materials Used in Classic Ceramics—Brief Introduction to Ceramic Chemistry—White Wares—Artware—Ceramics for Electrical and Electronic Uses—Dental Porcelain—Structural Clay Products—Refractories—Glass—Porcelain Enamel—Ceramic Abrasives—Cermets—New Developments in Ceramics—Appendix: Ceramic Raw Materials.



1961, 210 pages, $5.95

30-Day Free Trial Offer

MAIL THIS COUPON TODAY!

REINHOLD PUBLISHING CORPORATION
Dept. M-909, 430 Park Avenue,
New York 22, N. Y.

Send me Lee's CERAMICS for 30 days' Free Trial (*in U.S.A. only*) under the following terms:

- ☐ Purchase price enclosed (Reinhold pays postage)
- ☐ Bill me (plus postage)
- ☐ Bill company (plus postage)

Name .....
(Please print)
Address .....
City & Zone.....State.....
SAVE MONEY! Enclose $5.95 with order and Reinhold pays all shipping costs. Same return privilege guaranteed. Please add 3% sales tax on N.Y.C. orders. *Do not enclose cash!*

What's new IN MATERIALS

and called Speed-Insul, the insulation is supplied in sheets about 50 in. wide by 100 in. long.

The panels are fastened to metal surfaces using threaded studs welded to the surface to be insulated; the panels are predrilled to the studs. Studs, fastening nuts and washers are supplied with the system. The metal-faced sheets can be cut and drilled in the field.

KEY NO. 638

Rubber-Base Adhesive Applied in Dry Form

A high strength synthetic rubber-base adhesive can be applied in a relatively dry form with a new spray technique, details of which have not been revealed. Depositing the adhesive in a dry form is said to eliminate most of the solvent in the applied adhesive, thus permitting application to polystyrene foam without causing deterioration.

Designated EC-1828, the adhesive is available from the Adhesives, Coatings and Sealers Div. of Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

According to 3M, the adhesive requires only contact pressure to bond steel, aluminum, wood, foamed glass and particle board to themselves and to other materials. A big potential use for the adhesive is in bonding honeycomb sandwich panels.

The adhesive has high strength properties over a service temperature range of —30 to 250 F. It meets military specification MIL-P-8053B. One gallon covers over 300 sq ft of bonding surface. KEY NO. 639

Vinyl Insulation

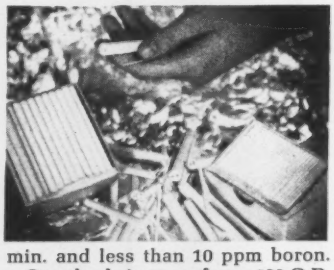
A transparent vinyl insulation sleeving is said to combine outstanding heat resistance with good resist-

High Purity CRUSHABLE CERAMIC PREFORMS meet Government Specs.

Crushable ceramic preforms for precision swaged thermocouples for atomic energy and turbine engine applications are available from Carborundum.

The following materials exceed the requirements of A.E.C. Specification SPC-SR-101-(ORO), Oak Ridge National Laboratories Specification ORNL Spec. 7444-1 and Knolls Atomic Power Laboratories ORPM 7-1.

1. *High Purity Magnesium Oxide*—Type 0333, certified purity 99.4% min. MgO and less than 25 ppm boron.
2. *High Purity Fused Aluminum Oxide*—Type 1513, certified purity 99.6% min. Al_2O_3 and less than 2 ppm boron.
3. *Stabilized Zirconium Oxide*—Type 0956, certified purity 91.9% min. and less than 10 ppm boron.



Standard sizes are from .022 O.D. with holes from .005. Standard preforms are offered for 1, 2 and 4 hole applications. Others are available on request.

For Technical Data Sheet and other information contact Dept. MD-111, Latrobe Plant, Refractories Division, Carborundum Co., Latrobe, Pennsylvania.

CARBORUNDUM®

Introducing a new type of "Armalon"

new "Armalon" FEP-fluorocarbon resin coated glass fabrics

After extensive development and testing, Du Pont now can offer "Armalon" FEP-fluorocarbon resin coated glass fabrics. The FEP resin has unique properties that enable this new "Armalon" to find applications in areas not appropriate to our regular TFE line of "Armalon".

Outstanding advantages of new "Armalon" FEP

- Uniform porosity resistance
- New lower melt point for easier lamination
- Good heat resistance
- Extreme toughness
- Abrasion resistance
- Excellent electrical properties over a wide range of temperatures and frequencies
- High degree of chemical inertness
- Smooth, anti-adhesive surface with anti-stick qualities

Comparison of properties of new "Armalon" FEP and "Armalon" TFE

PROPERTIES	FEP 503-108	TFE 403-108	FEP 505-112	TFE 405-112	FEP 506A-116	TFE 406A-116	FEP 510-128	TFE 410-128
Breaking Strength	65 x 40	45 x 35	130 x 65	75 x 60	160 x 160	90 x 90	260 x 220	200 x 175
Tear (Elmendorf)	16 x 6	10 x 5	21 x 8	15 x 10	13 x 14	12 x 12	49 x 39	40 x 40
Moisture Absorption	.23	.64	.18	.68	.30	.32	.276	.10
Burst	150	25	200	25	380	100	410	100

Characteristics of new "Armalon" FEP

The "Teflon" FEP-fluorocarbon resin coating on "Armalon" FEP gives this new material several outstanding properties (not provided by "Armalon" TFE). For example, the FEP resin has a lower melt point (545°F. to 563°F.) than the TFE resin. This recommends the use of "Armalon" FEP as a coating on glass fabrics that are to be heat-sealed. In addition, FEP dispersion-coated glass fabrics have lower permeability, greater breaking strength and lower moisture absorption than "Armalon" TFE.

You may want a material that doesn't crack when creased under moderate pressure. "Armalon" FEP won't. There is no known solvent for its FEP resin coating, and it is unaffected by aqua regia and all known chemicals except molten alkali metals. Corrosive materials and atmospheric conditions have no effect on it.

"Armalon" FEP remains flexible after long exposure to high temperatures, and pliable at temperatures lower than -100°F. Of particular significance are the improvements in burst strength and moisture absorption in the higher resin, lower glass qualities (see Qualities 503-108 and 505-112).

Suggested uses for new "Armalon" FEP

An important use for new "Armalon" FEP is in the wrapping and fusing operations for pipe covering, roll covering and chemically resistant containers. We also recommend these new materials for gaskets and specialized diaphragms, because of their satisfactory levels of uniform porosity resistance.

Industries that should find new "Armalon" FEP useful are aircraft, chemical, food processing, packaging, paper, plastics, printing, rubber, textile and various other industries.

FOR EXAMPLE: Conveyor belts used in baking, candy and food industries where sanitation and ease of release are important—Non-sticking covers for heat-sealing bars on packaging equipment—Diaphragms for regulators and control instruments where heat and chemical resistance are required. These are a few suggested uses for new "Armalon" FEP—there are many, many more. What application does this new product suggest to you?

For complete information on new "Armalon" FEP, its application and uses, write: E. I. du Pont de Nemours & Co. (Inc.), Fabric Sales, Wilmington 98, Delaware.

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

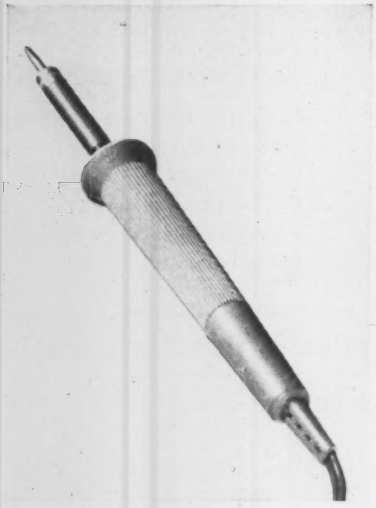
"ARMALON" COATED GLASS FABRICS

"Armalon" is Du Pont's trademark for its FEP and TFE fluorocarbon resin-coated fabrics and laminates.

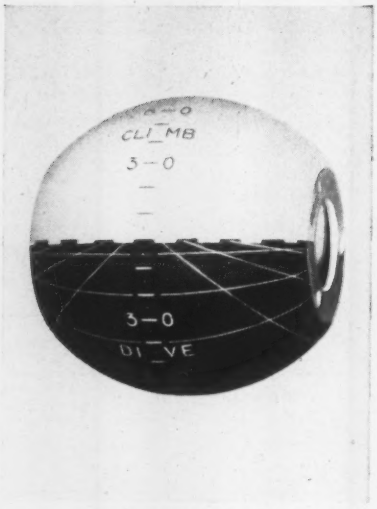
For more information, turn to Reader Service card, circle No. 338

G-E LEXAN® POLYCARB

STABLE ELECTRICALS. Binding posts made of LEXAN resin retain electricals even under moist, hot conditions. They do not loosen, are molded in six attractive LEXAN colors for coding. Other features are: low loss and power factor, low dielectric constant, high voltage insulation, non-sink surfaces.
(Superior Electric)



HEAT RESISTANCE. Beautiful handles of LEXAN polycarbonate resin are used in rugged service on U.L. approved soldering irons. They resist the impact, heat and abrasion of daily bench work. The hard, glossy handles are light in weight. Molded in three pastel colors, they provide toughness and sales appeal.
(Ungar Electric Tools)



DIMENSIONAL STABILITY. Maximum allowable change in this 5-inch aircraft instrument part is only 5 mils over a temperature range of —65° to 300°F! And it must maintain this tolerance under high humidity. Part is injection molded of LEXAN resin as half spheres which are solvent cemented, lathe-turned and painted. (Lear, Inc.)

PROPERTIES OF RESINITE HI-HEAT

Tensile Strength, psi	2900
Burst Strength, psi	75
Dielectric Strength, v/mil	1000

ance to oil and fungus attack. It is designed for electric motor insulation, transformer leads and other applications in both ground and airborne electronic assemblies.

The product's water clear color permits easy identification of print and color-coded wires. Called Resinite Hi-Heat 105C, the sleeving is available from Borden Chemical Co., 1 Clark St., North Andover, Mass.

The new insulation sleeving is said to surpass all requirements set forth in specification MIL-I-631C, Type F, Form U, Grade C, Classes I and II. The sleeving is suitable for use over the temperature range —10 to 221 F.
KEY NO. 640

Other News . . .

Metals

▸ Single crystals of copper for use in neutron spectrometers are available from Semi-Elements, Inc., Saxonburg Blvd., Saxonburg, Pa. The crystals measure 3 in. by 3 in. by ¼ in. thick and sell for $995 each.
KEY NO. 641

▸ A new spinning process can be used to spin tool steels and other hard-to-form materials in thicknesses up to ½ in. The process, developed by Phoenix Products Co., Phoenix-spun Div., 4711 N. 27th St., Milwaukee, can also be used to turn out disks in diameters up to 170 in.
KEY NO. 642

Plastics

▸ Lead, bronze, steel, copper and aluminum-filled silicone resins have been introduced by Furane® Plastics Inc., 4516 Brazil St., Los Angeles 39. The compounds, called Epocast H-1759, are basically rubberlike in character.
KEY NO. 643

▸ A flexible insulating material for Class 265 F (formerly Class B) applications is currently available from Westinghouse Electric Corp., Micarta Div., Trafford, Pa. The material, called No. 5J39, is composed of Dacron polyester warp fibers and glass fill fibers treated with an improved varnish. It is supplied as a tape and as a fabric.
KEY NO. 644

▸ A high strength epoxy-metal compound is designed to fill, bond and repair steel, iron, aluminum, bronze, brass, lead, ceramics, wood, glass, leather, fabrics and most hard plastics. The compound is available from Borden Chemical Co., 350 Madison Ave., New York 17. It can be machined, filed, sanded, drilled and tapped. It sets in 2 to 4 hr and cures overnight.
KEY NO. 645

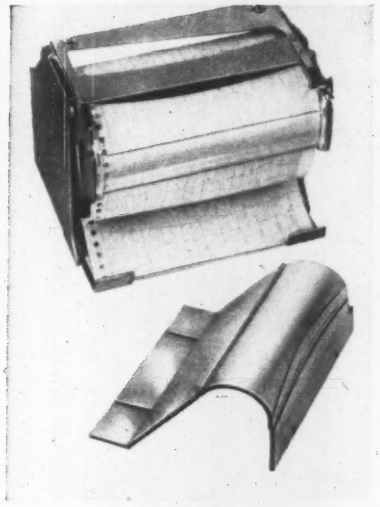
Other nonmetallics

▸ A new oriented ceramic permanent magnet material is particularly suited for use in microwave equipment. Produced by Indiana Steel Products Div. of Indiana General Corp., Valparaiso, Ind., the material has a coercive force of 3000 oersteds and a residual induction of 3300 gausses. It is designated Indox VI.
KEY NO. 646

▸ Metallized mica parts are now available in a variety of shapes and sizes from Micacraft Products, Inc., 53 Liberty St., Newark 5, N. J. The parts can be cut, stamped, shaped, machined or lathe-turned to customer specifications.
KEY NO. 647

▸ An economical-grade neoprene-abestos gasket material has been introduced by Rogers Corp., Rogers, Conn. Called Duroid 3115, the material has very high compressibility and excellent resistance to stress relaxation. It is recommended for use

ONATE RESIN GOOD DIELECTRIC— AND MUCH MORE!



TRANSPARENCY of LEXAN resin is important in chart guide for recorder. LEXAN resin is the only transparent plastic able to withstand heat generated by internal lights. It is distortion-free at temperatures up to 270°F and self-extinguishing. Its extremely high impact strength eliminates cracking of guides. (The Foxboro Co.)

TOUGHNESS. Press-fitted into metal gear used in an electric drill, bushing of LEXAN polycarbonate resin provides safety from electric shock . . . helps eliminate need for additional grounding. Strength and creep resistance of LEXAN resin enables bushing to withstand torque and load requirements of drill. (Millers Falls Co.)

ARE YOU LOOKING FOR A PLASTIC THAT CAN REALLY TAKE IT?

To demonstrate the toughness of LEXAN resin, salesmen will sometimes slam and hammer a product made of the material. LEXAN has the highest impact strength of any plastic – amounting to 12-16 foot-pounds per inch of notch – and it usually emerges unscathed from encounters with such "merchandising stresses". It is a high-performance material, likewise, with regard to high-temperature behavior and dimensional stability.

Its many other advantages make it a priority material for thorough investigation by all designers, engineers and molders. We will be pleased to supply you with information on the properties, processing and end-uses of LEXAN resin. Don't hesitate to write to us. General Electric, Chemical Materials Department, Section M-111, Pittsfield, Mass.

LEXAN®
Polycarbonate Resin
GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 458

with hot or cold oils in lubrication and hydraulic systems. KEY NO. 648

▸ TFE felt in widths up to 72 in. and in lengths up to 60 yd is now available from American Felt Co., 2 Glenville Rd., Glenville, Conn. The felt, called Feutron, is expected to be used for filtration applications and low friction cushioning pads. It can be used over the temperature range —100 to 400 F. KEY NO. 649

▸ A new line of vinyl-coated glass cloth has been introduced by Vulcan Div. of Reeves Bros., Inc., 1071 Avenue of the Americas, New York 18. The material is specially treated for fire resistance and flexibility. Called Coverlight-V, it is available in widths of 36 and 50 in. and in weights ranging from 5 to 20 oz. KEY NO. 650

Finishes

▸ A noninflammable metallic coating for expanded polystyrene foam has been developed by Adhesive Products Corp., 1660 Boone Ave., New York 60. Called Styro-Kote, the coating contains no solvent and will not attack expanded polystyrene or collapse it. It forms a flexible metallic skin on curing. KEY NO. 651

▸ A new polyurethane-base insulating coating is designed for use on printed circuit boards. The coating, called HumiSeal Type 1A28, is marketed by Columbia Technical Corp., 24-30 Brooklyn-Queens Expressway West, Woodside 77, N. Y. It can be used over the temperature range of –70 to 250 F. KEY NO. 652

▸ A liquid bright dip for cadmium has been introduced by Allied Research Products, Inc., 4004 E. Monument St., Baltimore 5, Md. Called Iridite No. 4L-1, the bright dip provides excellent corrosion protection and retains good solderability after long periods of storage. KEY NO. 653

▸ A transparent coating is designed for use on capacitors, resistors, transistors, diodes, coils, armatures, motor windings and other electronic parts. The coating, called HumiSeal Type 1F19, is a one-part material that dries tack-free at room temperature and is then oven cured. It is available from Columbia Technical Corp., 24-30 Brooklyn-Queens Expressway, West, Woodside 77, N. Y. Composition has not been disclosed. KEY NO. 654

▸ A new primer available from Interchemical Corp., Finishes Div., P. O. Box 659, Newark 1, N. J. is said to provide excellent adhesion of plastisol coatings to nylon fabrics. Designated SBC-2047-1, the primer is supplied in two parts. KEY NO. 655

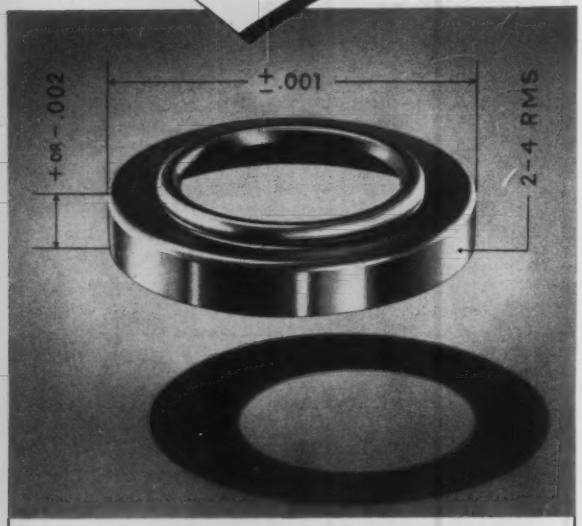
Joining & fastening

▸ A new silicon bronze welding rod is suitable for use with the tungsten inert-gas, carbon arc and oxyacetylene welding processes. Designated Airco 1010, the rod is available from Air Reduction Sales Co., Div. of Air Reduction Co., Inc., 150 E. 42nd St., New York 17. The rod can be used for welding silicon bronze wrought and cast materials, as well as weldable grades of copper and copper alloys. It is supplied in diameters from 1/16 to 5/16 in. KEY NO. 656

▸ A silver-filled epoxy adhesive called No. 2015 has been introduced by the Adhesive Enginering Div. of Hiller Aircraft Corp., 1411 Industrial Rd., San Carlos, Calif. The conductive adhesive bonds strongly to metal, glass, ceramics and most plastics. KEY NO. 657

▸ Tygoweld 54 is the name given to a two-part, modified epoxy adhesive introduced recently by United States Stoneware Co., Adhesives Div., P. O. Box 624, Stow, Ohio. The adhesive can be used to bond metal or nonmetallic materials to core materials. KEY NO. 658

Completed with ONE Stroke of the Press!



Reichert Methods Pay Off

QUALITY CONTROLLED STAMPINGS

Exacting Tolerances

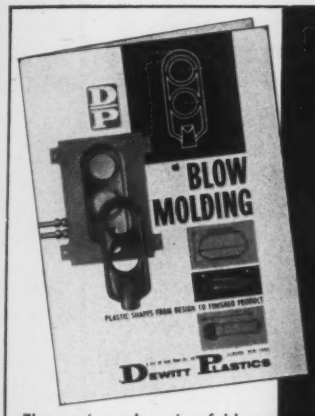
Deep Drawn, Light and Medium
COPPER
BRASS
ALUMINUM
MONEL
STAINLESS
HIGH CARBON
ALLOY STEELS

FORMING • DRAWING • DRILLING
BLANKING • PIERCING • TAPPING
TESTING • ANNEALING • SWEDGING
• ASSEMBLING
• HEAT TREATING
• SILVER BRAZING

Write for brochure

The Reichert **FLOAT & MFG. CO.**
Established 1924
2271 SMEAD AVENUE • TOLEDO 6, OHIO

For more information, turn to Reader Service card, circle No. 426



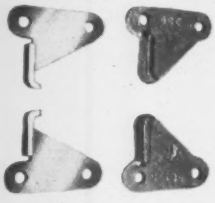
The pro's and con's of blow molding are described in DeWitt's new illustrated bulletin on blow molding. It describes its function, advantages, limitations and economies, as well as providing a handy checklist of Do's and Dont's in design to take maximum advantage of this new technique.

Write now for new informative bulletin A1A-7

DEWITT PLASTICS AUBURN, N. Y.

can BLOW MOLDING really cut costs by 1/4 to 1/2 ?

For more information, turn to Reader Service card, circle No. 376



Lighter **STRONGER** lower cost!

changed from bronze casting to Pressed Steel Stamping

Conversion from casting to stamping saved a Skokie, Illinois manufacturer of production line chains $142.40 on an initial order of replacement links that also proved lighter and stronger.

SMALL LOT TECHNIQUE USING TEMPORARY TOOLS SAVES $142.40

Dayton Rogers' short-run metal stamping facilities will handle blanks 22" square, material up to 3/8" thick, and drawing up to 4 1/4" deep.

Send your sketch, blueprint or part, plus quantity, for prompt quotation.

DAYTON ROGERS *Manufacturing Company*
MINNEAPOLIS 7X, MINNESOTA

For more information, turn to Reader Service card, circle No. 430

Now in the hands

of all M/DE subscribers . . .

1961-62 MATERIALS SELECTOR ISSUE

The year's biggest boon to those time-pressed engineers, designers, and other technical men who select and specify engineering materials, forms and finishes! This new MATERIALS SELECTOR issue is bigger and better than last year's edition.

All editorial pages in the MATERIALS SELECTOR issue are in data sheet form to provide you with quick comparisons of properties and applications of hundreds of metals; nonmetallics; forms and shapes; and finishes and coatings. Keep the SELECTOR issue on your desk for ready reference. You'll find it a real time saver.

The MATERIALS SELECTOR issue is available to *Materials in Design Engineering* subscribers only.

Materials In Design Engineering

A Reinhold Publication

430 Park Avenue · New York 22, N. Y.

INTRICATELY FLUTED . . . and

Automatically FINISHED TO PERFECTION

Many thousands of these and other parts are being fabricated daily here at Sinko for one of America's leading manufacturers of major electrical appliances.

And the reason we continue to enjoy their business is because our many years of experience and know-how, and our excellent production facilities, enable us to deliver *perfect moldings always . . . at low cost* and with dispatch.

We mold all Thermoplastics—from 2 to 175 oz.

Write TODAY for illustrated Brochure!

Sinko MANUFACTURING and TOOL CO.

7310 W. WILSON AVE. • CHICAGO 31, ILL.

Offices in Principal Cities Throughout the United States

For more information, turn to Reader Service card, circle No. 351

SPRAY . . . BRUSH . . . ROLL

Adheron*

epoxy coatings

METAL . . . WOOD . . . MASONRY

STOP ACID ATTACK

Send for free literature today. Learn how Adheron epoxy products can help you cut maintenance costs. Get *positive* protection against acids, alkalis and corrosive fumes.

*** Proven during more than 5 years of industrial use**

Hauger-Beegle

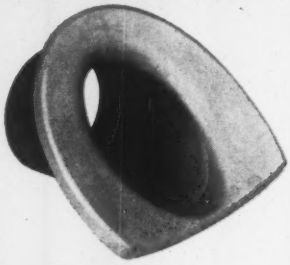
ASSOCIATES, INCORPORATED

7250 Franklin Street • Forest Park, Illinois

For more information, turn to Reader Service card, circle No. 448

HI-TEMPERATURE METALS

Tungsten
Molybdenum
Tantalum
Columbium
and
Others



NOW—for the first time

FABRICATED - WELDED - MACHINED

Super-Temp Corporation now can offer **complete fabrication** of light or heavy sheet of pure tungsten, molybdenum, tantalum-tungsten and other high temperature metals into almost any shape desired for missiles, space and re-entry vehicles.

Super-Temp's ability to successfully weld segmented parts and assemblies of pure tungsten and other high temperature refractory metals opens up a wide new area for the design and use of these metals. Complete facilities are available for the custom machining, bonding and flame spraying of the heat sinks and insulations necessary for high temperature package assemblies.

SERVICES

Fabrication—Machining
Die Forming—Spinning
Flame Spraying—Bonding
Engineering—Assemblies

PART APPLICATIONS

Nozzles, Liners, Throat Inserts, Rings, Flanges, Shields, Blast Tubes, Elbows, Venturi Shapes, Cones, Flame Barriers, Structure Applications and Others.

Super-Temp Corporation

2024 W. 15th St., Long Beach 13, Calif.
Phones—HEmlock 6-9236 . . SPruce 5-1600

For more information, turn to Reader Service card, circle No. 470

STATEMENT OF THE OWNERSHIP, MANAGEMENT AND CIRCULATION REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, JULY 2, 1946 AND JUNE 11, 1960 (74 Stat. 208) of MATERIALS in Design Engineering, published monthly with an additional issue in Mid-October, at New York, N. Y., for October 1, 1961.

1. The names and addresses of the publisher, editor and managing editor are: Publisher, William P. Winsor, 400 East 52nd Street, New York 22, N. Y.; Editor, H. R. Clauser, Valley Lane, Windmill Farm, Armonk, N. Y.; Managing Editor, John B. Campbell, 75-20 113th Street, Forest Hills, L. I., N. Y.

2. The owner is: Philip H. Hubbard, 2 Bon Mar Road, Pelham Manor, N. Y.; William P. Winsor, 400 East 52nd Street, New York 22, N. Y.; Profit Sharing Trust, 430 Park Avenue, New York 22, N. Y.; Fred P. Peters, 45 Forest Drive, Short Hills, N. J.; H. Burton Lowe, 18 Onderdonk Avenue, Manhasset, L. I., N. Y.; Merald Lue, 6 Bluewater Lane, Westport, Conn.; Kathleen Starke, 266 Bedford Park Boulevard, Bronx 58, N. Y.; John Y. Cunningham, 209 East 56th Street, New York 22, N. Y.; John F. Le Viness, Jr., 10 Oak Street, Floral Park, L. I., N. Y.; Gessner G. Hawley, 328 West 58th Street, New York 19, N. Y.; David B. Wilkin, 80 Devoe Road, Chappaqua, N. Y.

3. The known bondholders, mortgagees and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: None.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders, who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

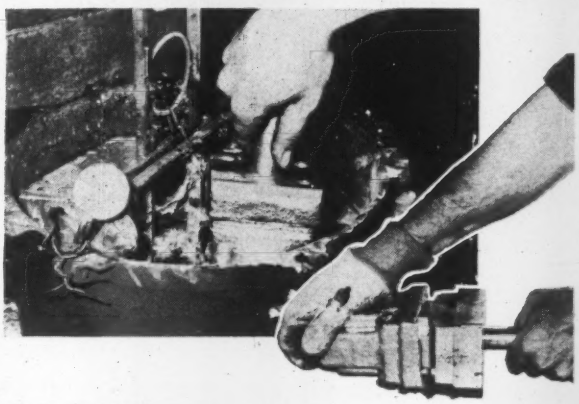
5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: 29,040.

William P. Winsor,
Publisher.

Sworn to and subscribed before me this 3rd day of October, 1961.
(SEAL)

Kathleen Starke,
Notary Public.
(My commission expires March 30, 1962.)

CERROTECHNICS *saves* TIME & MONEY
in Making Dip Molds



CERROTECHNICS—
The technology of using CERRO* ALLOYS to expedite industrial operations.

CERROTRU makes remarkable savings in dip molds for encapsulating electronic components. A polished metal master pattern is immersed in molten CERROTRU. The shell freezing to the pattern is removed, becoming the mold for the epoxy. Send for full information.

*T.M. Cerro Corp.

CERRO SALES CORPORATION
SUBSIDIARY OF CERRO CORPORATION
Room 1504, 300 Park Avenue, New York 22, N. Y.

For more information, turn to Reader Service card, circle No. 349

SEE HOW FELT CAN IMPROVE YOUR PRODUCT!

CONTINENTAL FELT COMPANY, since 1905, has been supplying America's leading companies with more than 300 grades of felt, in wool or synthetics.

Of particular interest to you may be our new technical bulletin, "Comparative Properties of Industrial Felt". This FREE copy shows you immediately which felt to use!

Your inquiries will be handled promptly. Our laboratories and engineering departments are at your service.

STOCKED FOR PROMPT DELIVERY • CUT TO YOUR REQUIREMENTS

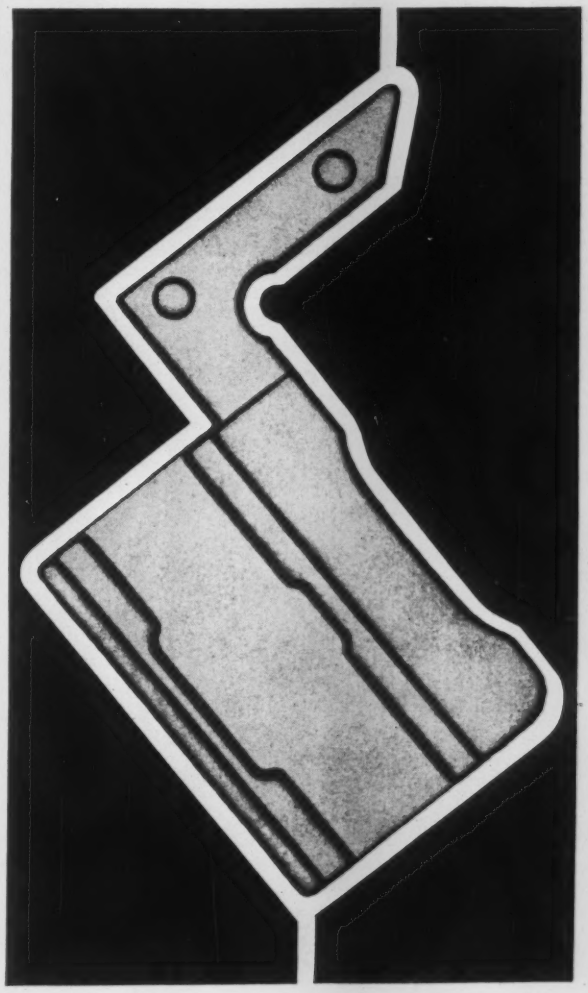
CONTINENTAL FELT COMPANY
22-26 WEST 15th STREET NEW YORK 11, N. Y.

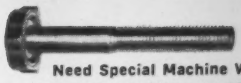
For more information, turn to Reader Service card, circle No. 419

RITCO FORGED
smooth "bright finish" reduces your product costs

The flaw-free, accurate surfaces of Ritco "Bright Finish" Forgings save costly finishing . . . also greatly reduce machining time. The further advantage of tremendous toughness in Ritco Forgings, due to controlled grain flow, assures the highest ratio of strength to weight and dependable impact resistance at points of greatest shock and stress. It will pay you to learn more about Ritco "Bright Finish" Forgings. Send us your blueprints for estimates.

RHODE ISLAND TOOL COMPANY
Member Drop Forging Association
154 WEST RIVER STREET • PROVIDENCE 1, R. I.





Need Special Machine Work—or Special Fasteners and Upsets? Our machining facilities are at your service. Let us know your requirements!

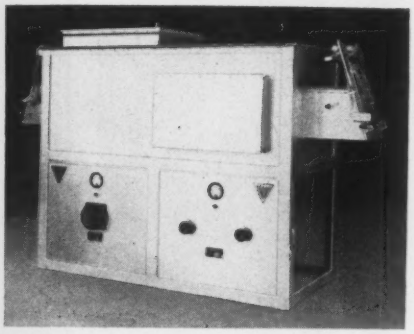
For more information, turn to Reader Service card, circle No. 390

FOR TOP OF THE LINE MODELS

A
B
C
Magic Chef®
TURNS TO G.E.I.
Instrument panels of Magic Chef ranges are framed in the magic metal—aluminum . . . extruded, fabricated and anodized by GENERAL EXTRUSIONS, INC. This is another example of a leading manufacturer solving his requirements for durability, beauty and utility with G.E.I.'s uniform quality and unfailing delivery. Discuss your extruded aluminum needs—one part or a million—with G.E.I.
GENERAL EXTRUSIONS, INC.
4040 Lake Park Road, Youngstown, Ohio
Sales Offices at St. Louis, Pittsburgh, Chattanooga, Cincinnati and Cleveland
Consult your classified phone book under Aluminum Products
C BACKGUARD TOP
A BACKGUARD BOTTOM
TRIM FRONT CENTER
B
MOUNTING BRACKET

For more information, turn to Reader Service card, circle No. 401

2900°F and 2300°F *Simultaneously*



An ideal furnace for critical heat treating processes

Two zones employing two types of heating elements, and each having its own controls! That's how these two high temperatures are accomplished at the same time in this Pereco Straight-Line Furnace. And for the ultimate in precise control, each zone also has its own saturable core reactor system. Depending upon the work requirements, Pereco also offers in this same SNX Series of Furnaces any multiple or combination of pre-heat, high temperature or cooling zones. So, write Pereco for recommendations for handling your specific needs.

PERECO

Straight-Line Furnaces
Pereny Equipment Co., Inc.
Dept. "A", 893 Chambers Road
Columbus 12, Ohio

PERENY EQUIPMENT COLUMBUS OHIO

For more information, turn to Reader Service card, circle No. 437

* Leather • Asbestos • Nylon • Vinyl • Teflon • Silicone Rubber • Neoprene • Rubber Cork • Fibre • Compositions • Phenolics • Cloth • Felt • Paper • Cardboard • Plastics Brass • Steel • Copper • Aluminum • Kel-F • Viton A • Mylar • Other Special Materials

Send specifications or blueprints for prompt quotations and recommendations. No obligation.

THE AUBURN MANUFACTURING CO.
301 Stack St., Middletown, Conn.

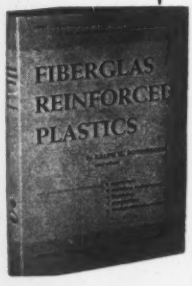
New York, N. Y.; Rochester, N. Y.; Detroit, Mich.; Chicago, Ill.; Minneapolis, Minn.; Pittsburgh, Pa.; Cincinnati, Ohio; Ridgewood, N. J.; Atlanta, Ga.; Memphis, Tenn.; St. Louis, Mo.; Washington, D. C.

For more information, turn to Reader Service card, circle No. 418

Here's latest information on a phenomenal new structural material!

FIBERGLAS REINFORCED PLASTICS

Edited by
RALPH H. SONNEBORN
Technical Service Dept.,
Plastics Reinforcement Division,
Owens-Corning Fiberglas Corporation



1954, 250 pages, $4.50

This valuable book offers the first *complete* treatment ever published on the subject of reinforced plastics, the amazing post-war structural material that has found its way into scores of new industries and products.

Written for both design engineers and executives in the materials industries, the book covers in full detail the resins and glass reinforcements used in reinforced plastics, molding techniques, inspection and testing, properties, and design considerations.

This important book will provide all those concerned with reinforced plastics—molders, materials suppliers, government agencies, engineers—with a wealth of information never before available in a single volume.

Order now for 10 days' FREE EXAMINATION
REINHOLD PUBLISHING CORPORATION
Dept. M-910, 430 Park Avenue, New York 22, N. Y.

For more information, turn to Reader Service card, circle No. 494

WECKESSER

molded
BLACK NYLON
SCREWS
and
NUTS

Acid resistant . . .
Need no insulation . . .
Can't rust . . .
Can't corrode . . .

● **CUT ASSEMBLY TIME**

2-56, 4-40, 6-32, 8-32, 10-32 and ¼-20 in stock. Actual production samples will give you the whole story. Write on your letterhead.

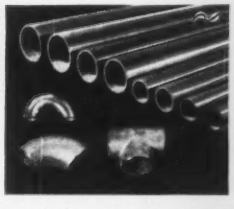
WECKESSER COMPANY
5713 Northwest Hwy. • Chicago 46, Ill.

For more information, turn to Reader Service card, circle No. 350

500° ABOVE-400° BELOW CAN'T "KO"

In services up to +500°F and down to –400°F, AMPCO metal retains an unusually high percentage of its room-temperature characteristics. It is available in most any form.

AMPCO® metal



Get the facts about this series of special copper-base alloys that performs dependably at high (plus 500° F.) and low (minus 400° F.) temperatures. Contact your nearby Ampco Field Engineer for detailed information or send for free literature — do it today.

AMPCO METAL, INC. DEPT. 10K, MILWAUKEE 1, WIS. G-7
WEST COAST DIV.: HUNTINGTON PARK, CAL.
SOUTHWEST DIV.: GARLAND (DALLAS COUNTY), TEX.

For more information, turn to Reader Service card, circle No. 435

determines scratch-dig-scrape resistance of organic materials and coatings

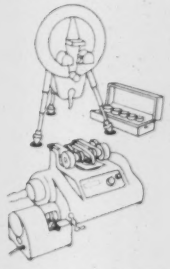
Easy to use, this precision-made instrument measures the ability of a rigid organic material to resist scratches, digs, and scrapes not classed as ordinary wear.

Applications are numerous. Three interchangeable cutting tools are provided for making shear and scratch resistance tests on a wide variety of specimens (up to ¼" thick). Even the adhesive quality of coatings can be rated.

For full details on this and other Taber testing instruments, simply fill in and mail the coupon below.

STIFFNESS TESTER MODEL 150-B
Determines initial stiffness, basic stiffness and resilience of flexible materials (up to ⅛" thick) such as metals, plastics, paper, boxboard, cellophane, wire, and metal foils.

ABRASION TESTER MODEL 174
Measures wear life (or abrasion resistance) of metals, plastics, paints, rubber, textiles, linoleum, etc. under simulated conditions of actual use.



TABER INSTRUMENT CORP., SECTION 244,
109 GOUNDRY ST., NORTH TONAWANDA; N. Y.

MAIL bulletin(s) describing
☐ Abraser ☐ Stiffness Tester ☐ Shear/Scratch Tester

Name
Title
Company
Street
City Zone State

For more information, turn to Reader Service card, circle No. 389

Products Advertised

Note: This index includes all advertisers whose copy was received by closing date, the 5th of the month preceding month of issue. Every effort has been made to insure accuracy, but the publisher does not assume responsibility for errors or omissions.

Use this index to *keep up to date* by looking up the advertisements on those materials in which you are most interested, on pages listed below.

***Get more information* on advertised products by circling the key numbers found on the advertisements *(not the page numbers below)* on the free postal card, pp 43-44.**

Abrasives 101
Adhesives .....20, 72, 92, . 5, 189
Aluminated flexible materials ... 26
Aluminum and its alloys..37, 156, 197

Bimetals, thermostatic 184
Books, technical 168
Brazing alloys 108, 154, 185

Carbides 56
Carbon, graphite 149, 192
Casting alloys 154
Castings
- Centrifugal 76
- Continuous 61
- Corrosion resistant 158
- Die 2, 18, 23, 96
- Investment 192
- Shell mold 192

Ceramics 14, 88, 144, 198, 200
Ceramoplastics 28-29
Clad metals 48-49
Cleaners, metal 104
Cleaning, ultrasonic 25
Coatings
- Ceramic 157
- Chemical conversion 78-79, 80, 155, 162
- Electroless plating 107, 177
- Flame plated 101
- High density 50
- Metallic 107, 177
- Organic 191, 204
- Plasma 101, 105
- Plastisol 187
- Vacuum deposited 194

Copper and its alloys.....inside front cover, 73, 209
Corrosion resistant alloys 64

Drawn, pressed parts 204

Extrusions
- Metallic 208
- Nonmetallic 180

Fabricated parts 70-71, 206
Fabrics, coated 54, 201
Fasteners, mechanical 70-71, 75, 82, 95, 194, 209
Felts .....207, inside back cover
Forgings 164, 168-169, 207
Furnaces 208

Gaskets 208

Hard facing alloys 154

Impact extrusions 168-169
Insulation 28-29

Laminates
- Metal-plastic 75
- Plastics 75

Lead and its alloys 175
Low melting alloys 207
Lubricating materials 186

Metal powder parts....90-91, 168-169
Metal powders 3
Mica, glass-bonded 28-29

Nickel and its alloys 4, 58, 179

Packings 208
Plastics
- ABS 16, 30-31
- Acetal 59-60
- Acrylic 161
- Epoxy 151, 204
- Fluorocarbon 152, 160
- Foam 160
- Phenolic 94, 147, 173
- Polyamide (nylon) 152
- Polycarbonate 202-203
- Polyester (film) 110
- Polyester 173
- Polyethylene 40, 193
- Polypropylene 33-36, 40, 65-69, 83, 89, 102-103, 165
- Polystyrene 38-39, 40
- Reinforced 94, 188
- Urea 77, 159
- Vinyls 6

Plastics moldings 57, 204, 206
Precious metals 185
Precision parts, metal 166
Precoated and preplated metals.....37, 62-63, 84, 182
Pressure vessels 174
Quartz, fused 185
Rayon fibers 97
Rings
- Metallic 148
- Nonmetallic "O" 85, 208

Rubber
- Moldings 180, 183
- Natural 183
- Silicone 72
- Synthetic 32, 180, 183
- Urethane 51, 150

Screw machine parts 168-169
Sealing alloys, ceramic-metal..... 176
Seals 208
Shims 208
Silicones 106, 139-140, 195
Spinnings 190, 206
Stampings, punchings 204, 206
Steel
- Carbon 199
- Heat and corrosion resistant..58, 93, 98-99, 181
- Leaded 8
- Low alloy 167, 179
- Specialty 86-87, 153
- Tool and die...81, outside back cover

Strip, precision rolled 52-53, 182
Tabletting machines 100
Temperature indicators 163
Testing equipment ..142, 146, 196, 209
Testing service 170
Thermocouples 190
Tubing and pipe
- Metallic 22, 24, 70-71, 73
- Nonmetallic 21

Weldments 206
Wire cloth 178
Wire forms 196
Wire, insulated 198
Wood 171
X-ray film 55
Zinc and its alloys.....2, 18

advertising sales staff

Materials in Design Engineering • *430 Park Ave., New York 22, N.Y.*

M. Randolph Long, *Advertising Sales Manager*

NEW YORK 22: District Managers, A. Stewart Hale, George L. Fox, Jr., 430 Park Ave., 212–MUrray Hill 8-8600. PHILADELPHIA 7: District Manager, R. A. Sommer, 12 South 12th St., 215–WAlnut 2-0346. CHICAGO 2: District Manager, Peter O. Johnson, 111 W. Washington St., 312–RAndolph 6-8497. CLEVELAND 14: District Managers, D. W. Huettner, H. Charles Esgar, 1717 East 9th St., 216–PRospect 1-4011. SAN FRANCISCO 5: District Manager, Roy M. McDonald, 625 Market St., 415–EXbrook 7-5377. LOS ANGELES 5: District Manager, Edwin T. Thompson, 3727 West 6th St., 213–DUnkirk 7-5391. PORTLAND 1, ORE.: District Manager, F. M. Eaton, 2035 S.W. 58th Ave., 503–CApital 2-5146. SEATTLE 4: District Manager, Harry Abney, 1008 Western Ave., 206–MAin 3-3766. DALLAS 19: District Manager, Parker Harris, 2727 Oak Lawn Ave., 214–LAkeside 1-1266. HOUSTON 6: District Managers, Frank N. Vickrey, William H. Gunn, Jr., 3217 Montrose Blvd., 713–JAckson 9-6711. DENVER 3: District Manager, Robert H. Heidersbach, 620 Sherman St., 303–TAbor 5-3325.

Advertisers and their Agencies

Use this index for the latest information on how and where to use *materials, forms and finishes* . . . because more companies advertise these products in the 13 issues of Materials in Design Engineering than in any other magazine.

Acheson Colloids Co. 186
Jaqua Advertising Co.
Acushnet Process Co. 150
S. Gunnar Myrbeck & Co., Inc.
Advance Tool and Die Casting Co. 23
Ken Seitz & Associates, Inc.
Aero Research Instrument Co., Inc...... 198
Brandt Advertising Co.
Allied Chemical Corp., Plastics Div.....33, 34, 35, 36
Benton & Bowles, Inc.
***Allied Chemical Corp., Plastics Div.** 77
McCann-Erickson, Inc.
Allied Research Products, Inc. 155
Emery Advertising Corp.
***Amchem Products, Inc.** 78, 79
Al Paul Lefton Co., Inc.
American Cyanamid Co., Plastics and Resins Div. 159
Erwin Wasey, Ruthrauff & Ryan, Inc.
***American Felt Co.** .....3rd Cover
Kelly, Nason, Inc.
American Lava Corp. 144
Designers, Inc.
***American Smelting and Refining Co., Continuous Cast Dept.** 61
Ward William & Co.
***American Steel & Wire Div., United States Steel Corp.** 52, 53
Batten, Barton, Durstine & Osborn, Inc.
***American Viscose Corp.** 97
Arndt, Preston, Chapin, Lamb & Keen, Inc.
Ampco Metal, Inc. 209
Hoffman, York, Paulson & Gerlach, Inc.
Anaconda American Brass Co. .....2nd Cover
Wilson, Haight & Welch, Inc.
Armco Steel Corp. 98, 99
Marsteller, Rickard, Gebhardt and Reed, Inc.
***Art Wire & Stamping Co.** 196
Williams and London Advertising
***Auburn Manufacturing Co.** 208
Williams and London Advertising
Avco Corp., Research & Advanced Development Div. 105
Benton & Bowles, Inc.
***AviSun Corp.** 65, 66, 67, 68, 69
Arndt, Preston, Chapin, Lamb & Keen, Inc.

***B B Chemical Co., Bostik Dept.** 145
Sutherland-Abbott
***Babcock & Wilcox Co., Tubular Products Div.** 22
Marsteller, Rickard, Gebhardt and Reed, Inc.
Bethlehem Steel Co. 81, 95, 167, 199
Hazard Advertising Co., Inc.
***Branson Instruments, Inc., Ultrasonic Power Div.** 25
Faulkner Advertising Inc.
Bridgeport Brass Co. 37
Marsteller, Rickard, Gebhardt and Reed, Inc.

Carborundum Co., Refractories Div. 200
G. M. Basford Co.
Carlson, G. O., Co., Inc. 181
Foltz-Wessinger Inc.
Carwin Co. 160
Langeler-Stevens Inc.
Ceilcote Co., Inc. 188
Penn and Hamaker, Inc.
***Cerro Sales Corp., Sub. of Cerro Corp.** 207
Thoma & Gill
Chace, W. M., Co. 184
Clark & Bobertz, Inc.
Chicago Rawhide Manufacturing Co. 85
Aves Advertising, Inc.
***Ciba Products Corp.** 151
Briggs & Varley, Inc
Cleveland Container Co. 21
Nesbitt Service Co.
Coast Metals, Inc. 154
Merritt L. Smith Advertising
Continental-Diamond Fibre Corp., Sub. of Budd Co. 75
Aitkin-Kynett Co., Inc.
***Continental Felt Co.** 207
Daniel H. Price, Inc.
Continental Rubber Works 180
Eugene C. Laird Advertising
Coors Porcelain Co. 14
Tallant/Yates Advertising, Inc.
Copperweld Steel Co. 8
Bayless-Kerr Co.

Delco Moraine Div., General Motors Corp. 90, 91
Campbell-Ewald Co.
Dewitt Plastics Div., Shoe Form Co., Inc. 204
Spitz Advertising Agency
Dixon Corp. 160
Horton, Church & Goff, Inc.
Doehler-Jarvis Div., National Lead Co. 96
McCann-Marschalk Co., Inc.
***Dow Chemical Co., Plastics Div.** 38, 39
MacManus, John & Adams, Inc.
Dow Corning Corp. 72, 139, 140
Church and Guisewite Advertising, Inc.
Driver, Wilbur B., Co. 176
George Homer Martin Associates
Du-Co Ceramics Co. 198
McHenry-Derek Advertising
du Pont de Nemours, E. I., & Co., Inc., Elastomer Chemicals Dept. 51
N. W. Ayer & Son, Inc.
du Pont de Nemours, E. I., & Co., Inc., Fabrics Div. 201
Batten, Barton, Durstine & Osborn, Inc.
du Pont de Nemours, E. I., & Co., Inc., Film Dept. 110
Batten, Barton, Durstine & Osborn, Inc.
***du Pont de Nemours, E. I., & Co., Inc., Polychemicals Dept.** 59, 60
Batten Barton Durstine & Osborn, Inc.
***Durez Plastics Div., Hooker Chemical Corp.** 173
Rumrill Co., Inc.

Eastman Chemical Products, Inc., Plastics Div. 165
Fred Wittner Co., Inc
Eastman Kodak Co., X-Ray Sales Div. 55
J. Walter Thompson Co.
Edgewater Steel Co. 148
Downing Industrial Advertising, Inc.
***Engelhard Industries, Inc.** 185
Stuart Sande Advertising
***Enjay Chemical Co., Div. of Humble Oil & Refining Co.** 89
McCann-Erickson, Inc.
***Enthone, Inc., Sub. of American Smelting and Refining Co.** 107
Ward William & Co.

***Frontier Bronze Corp.** 156
Harold Warner Advertising, Inc.

Gamble Brothers, Inc. 171
Doe-Anderson Advertising Agency, Inc.
***Garlock Inc.** 183
Hutchins Advertising Co., Inc.
General American Transportation Corp., Kanigen Div. 177
Edward H. Weiss and Co.
General American Transportation Corp., Plastics Div. 57
Edward H. Weiss and Co.
***General Electric Co., Chemical Materials Dept.** 147, 202, 203
G. M. Basford Co.
General Electric Co., Silicone Products Dept. 106
Ross Roy-Brooke, Smith, French & Dorrance, Inc.
***General Extrusions, Inc.** 208
R. J. McCallister Co.
***Goodrich, B. F., Chemical Co., Div. of B. F. Goodrich Co.** 6
Griswold-Eshleman Co.
Goodrich-Gulf Chemicals, Inc. 32
Griswold-Eshleman Co.
Grace, W. R., & Co., Polymer Chemicals Div. 40
de Garmo, Inc.
***Graphite Specialties Corp.** 192
Scheel Advertising Agency, Inc.
Great Lakes Steel Corp., Div. of National Steel Corp. 86, 87
Campbell-Ewald Co.
***Gries Reproducer Corp.** 194
Harold Marshall Advertising Co., Inc.

***Handy & Harman** 108
Hazard Advertising Co., Inc.
Hauger-Beegle Associates, Inc. 204
Adcraft Sales Promotion
Haynes Stellite Co., Div. of Union Carbide Corp. 64
J. M. Mathes Inc.
Hercules Powder Co., Inc. 102, 103
Fuller & Smith & Ross Inc.
Hughson Chemical Co., Div. of Lord Manufacturing Co. 20
Jayme Organization, Inc.

Instrument Specialties Co., Inc. 190
George Homer Martin Associates
International Nickel Co., Inc. 4, 58, 179
McCann-Marschalk Co., Inc.

La Salle Steel Co. 153
Fensholt Advertising Agency, Inc.
Lead Industries Association 175
O. S. Tyson and Co., Inc.
Libbey-Owens-Ford Glass Co., Liberty Mirror Div. 194
Fuller & Smith & Ross Inc.
***Linde Co., Div. of Union Carbide Corp.** .. 101
J. M. Mathes Inc.

***Marbon Chemical Div., Borg-Warner Corp.** 16
Hoffman-Kain Advertising
Materials in Design Engineering 172, 206
Materials Selector 205
McLouth Steel Corp. 93
Denman & Baker, Inc.
***Metal & Thermit Corp.** 187
Marsteller, Rickard, Gebhardt and Reed, Inc.
Midland Industrial Finishes Co. 191
Geyer, Morey, Madden & Ballard, Inc.
***Minnesota Mining and Manufacturing Co., Adhesives, Coatings and Sealers Div.** .. 92
MacManus, John & Adams, Inc.
***Monsanto Chemical Co., Plastics Div.** ..30, 31
Needham, Louis and Brorby, Inc.
***Mueller Brass Co.** 168, 169
Price, Tanner & Willox, Inc.
***Mycalex Corporation of America** 28, 29
Kelly, Nason, Inc.

Nanmac Corp. 190
Burton Advertising Corp.
***National Carbon Co., Div. of Union Carbide Corp.** 149
J. M. Mathes, Inc.
***New Jersey Zinc Co.** 2, 3
***Newark Wire Cloth Co.** 178
Sanger-Funnell, Inc.
Northwest Chemical Co. 80
E. B. Hubert Advertising Counselors
***Norton Co., Refractories Div.** 157
Chirurg & Cairns, Inc.
Nuclear Materials and Equipment Corp. .. 50
Peter Mehlich Inc.

***Oakite Products, Inc.** 104
Marsteller, Rickard, Gebhardt and Reed, Inc.
Olin Mathieson Chemical Corp., Metals Div. 197
Doyle • Dane • Bernbach • Inc.

***Parker Rust Proof Co.** 162
Fred M. Randall Co.
Pereny Equipment Co., Inc. 208
Wheeler, Kight & Gamey, Inc.
Phillips Chemical Co., Plastics Sales Div. .. 193
Lambert & Feasley, Inc.
Polymer Corporation of Penna. 152
Beaumont, Heller & Sperling, Inc.
Precision Castparts Corp. 192
Hugh Dwight Advertising
Pressed Steel Tank Co. 174
Buchen Advertising, Inc.

***Raybestos-Manhattan, Inc., Adhesives Dept.** 189
Gray & Rogers
***Raybestos-Manhattan, Inc., Reinforced Plastics Dept.** 94
Gray & Rogers

Reeves Brothers Inc., Vulcan Div. 54
Ketchum, MacLeod & Grove, Inc.
***Reichert Float & Mfg. Co.** 204
Wendt Advertising Agency
Reinhold Publishing Corp. 200, 208
***Republic Steel Corp.** 70, 71
Meldrum & Fewsmith, Inc.
***Rhode Island Tool Co.** 207
Horton, Church & Goff, Inc.
Riehle Testing Machines Div., American Machine and Metals, Inc. 142
L. W. Ramsey Advertising Agency
***Rochester Products Div., General Motors Corp.** 73
D. P. Brother & Co.
Rogers, Dayton, Manufacturing Co. 206
Keystone Advertising, Inc.
Rohm & Haas Co., Plastics Div. 161
Arndt, Preston, Chapin, Lamb & Keen, Inc.
Russell, Burdsall & Ward, Bolt & Nut Co. .. 82
Marsteller, Rickard, Gebhardt and Reed, Inc.

***St. Joseph Lead Co.** 18
Emil Mark & Co., Inc
***Sandusky Foundry & Machine Co.** 76
Howard Swink Advertising Agency, Inc.
Scott Testers, Inc. 196
Horton, Church & Goff, Inc.
***Silicones Div., Union Carbide Corp.** 195
J. M. Mathes Inc.
***Simmons Fastener Corp.** 74
Fred Wittner Co.
Sinko Manufacturing and Tool Co. 206
Allen J. Siegel Advertising
***Somers Brass Co., Inc.** 182
Charles Palm & Co., Inc.
Stokes, F. J., Corp. 100
Aitkin-Kynett Co., Inc
Super-Temp Corp. 206

Taber Instrument Corp. 209
Harold Warner Advertising, Inc.
Tempil Corp. 163
RAF Advertising Inc.
***Texas Instrument Inc., Metals & Controls Div.** 48, 49
Horton, Church & Goff, Inc.
***Thermo-Chem Corp.** 26
Rockett & Schaefer Advertising Agency
Timken Roller Bearing Co., Steel & Tube Div. ..... Back Cover
Batten, Barton, Durstine & Osborn, Inc.
Titan Metal Manufacturing Co., Div. of Cerro Corp. 164
Sykes Advertising, Inc.
Torrington Co., Specialties Div. 166
Hazard Advertising Co., Inc.

***Union Carbide Plastics Co., Div. of Union Carbide Corp.** 83
J. M. Mathes Inc.
United States Stoneware Co., Alite Div. .. 88
Ralph Gross Advertising, Inc.
United States Testing Co., Inc. 170
W. L. Towne Co., Inc.

Van Huffel Tube Corp. 24
Chamberlin-Junk Advertising Inc.
Vascoloy-Ramet Corp. 56
E. R. Hollingsworth & Associates

***Waukesha Foundry Co.** 158
Chandlers
Weckesser Co., Inc. 209
Butz, Campbell & Co., Inc.
Weirton Steel Co., Div. of National Steel Corp. 84
Campbell-Ewald Co.
***Wheeling Steel Corp.** 62, 63
Cunningham & Walsh Inc.
Wiley, John, & Sons, Inc. 168
Needham & Grohmann Inc.
Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc. 146
Reincke, Meyer & Finn, Inc.

These manufacturers advertised their products in the 1961

MATERIALS SELECTOR REFERENCE DATA ISSUE

For more complete information, and application data on their lines, refer to the Index to Advertisers in the Mid-October MATERIALS SELECTOR ISSUE of MATERIALS IN DESIGN ENGINEERING.

The last word

editor

by H. R. Clauser

Value Engineering

What Is It? Who's It For?

"Value engineering," the lead-off feature article in this issue (p 111) states, "is a method of finding the least expensive way to make a product." What's so unusual or different about that, you might ask? Or, isn't that what all engineers try to do?

Actually, there *is* nothing new about the objective of value engineering, which is reducing costs. But the rational approach and the set of techniques and procedures that have been developed in recent years to achieve that objective are relatively new and are saving many companies millions of dollars.

Materials Are a Major Area

The largest and most profitable area in which value engineering can be and is being applied is the field of materials and processes. There was a time, however, when value engineering in this area was practically impossible. This was when there were relatively few engineering materials, and when single materials had virtual monopolies in certain markets or for certain applications. Also, this was when a majority of engineers were usually content to keep their products within the economic and property limits of the materials they happened to be using.

But those days are gone forever. The tremendous increase in the number and variety of materials coupled with the rise of new and more stringent service and cost requirements has made certain of that. No longer are materials users content to live with a given material. No longer are they willing to fit their product designs to a particular material's set of properties. In developing and designing new products, the major concern now is to find and apply a material or materials with the right combination of properties to meet a pre-established set of performance and economic requirements. And in reviewing old products, materials users have adopted the practice of constant reappraisal of their materials selections to lower costs and improve product performance.

So it is out of these relatively new engineering attitudes, which are end-service oriented, that the systematic practices of value engineering have developed.

Not Merely for Specialists

And now that the value engineering techniques have proved so effective, they should be added to the tool kits of all those involved in product design and manufacture. However, there has been a tendency on the part of many to regard the application of value engineering concepts as the province of specialists. For example, the article in this issue advocates separate value engineering groups.

But value engineering should not be treated as an esoteric discipline intended for or understood by only a chosen few. Granted, value engineering specialists are needed to develop and refine techniques and to educate others. But in the long run, the application of value engineering is the job of whole engineering departments. For greatest effectiveness, the techniques must be absorbed by all design and materials engineers and used in their constant quest for better products and lower costs.

engineered problem solvers

A+ FELT PRECISION FABRICATED PARTS

ADD the benefits of our diversified fabricating techniques to the world's most versatile engineering and design material . . . A+ Felt . . . in a complete selection of wool and synthetic fibers . . . manufactured, impregnated, coated or treated to meet your special requirements . . . AND GET: One-source responsibility, assuring economical solutions to your engineering and design problems.

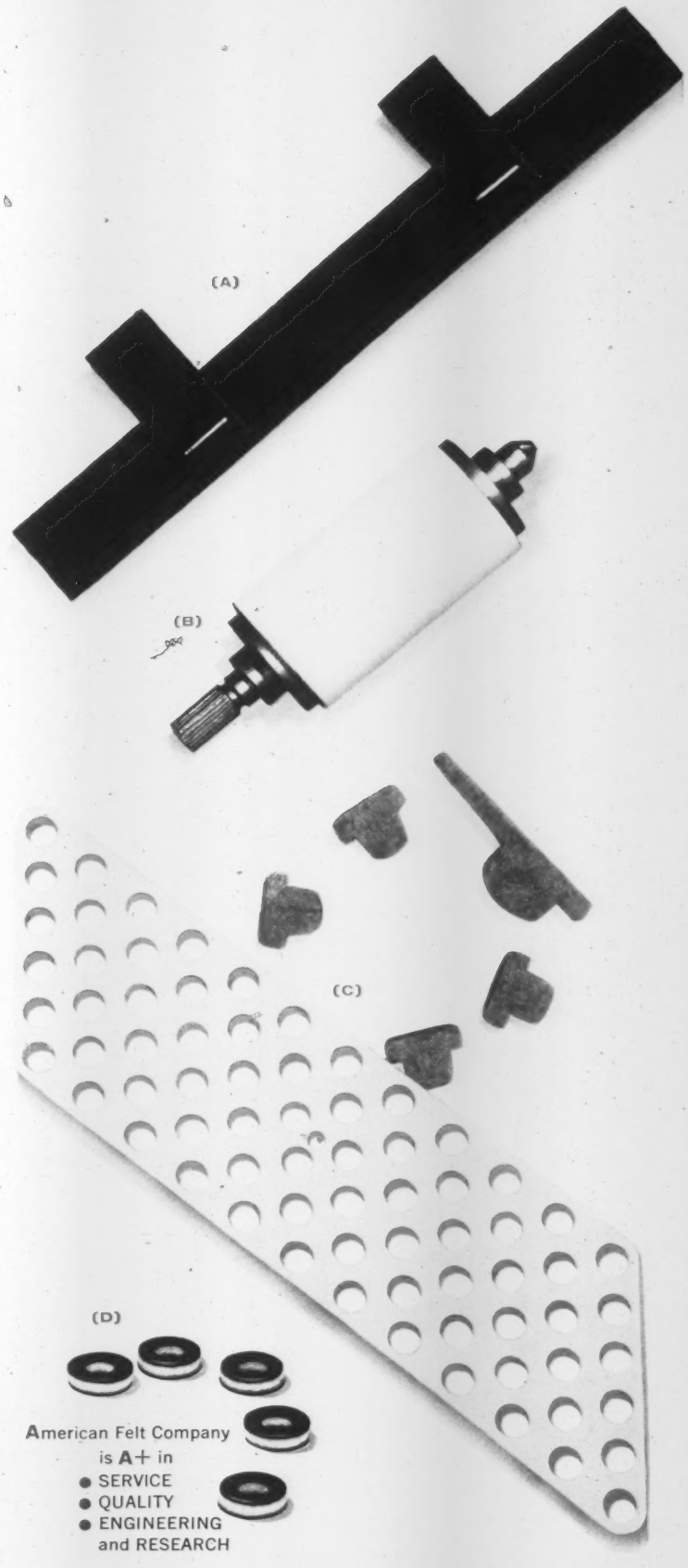
Our fabricating techniques include:

MACHINING
MOLDING
SKIVING
STRIPPING and STAPLING: **(A)** A+ Felt oil wick lubricator designed by AFCO engineers.
SHAPING
EXTRUDING
GRINDING: **(B)** A+ Felt ink roller.
CEMENTING
GROMMETING
DIE CUTTING: **(C)** A+ Felt electric motor wicks; keyboard cushion.
PERFORATING
DRILLING
LAMINATING: **(D)** A+ Felt and rubber laminated oil seals.
STITCHING

RAPID SERVICE . . . from our nationwide precision fabricating facilities located at Glenville, Connecticut; Detroit; San Francisco and Los Angeles . . . serving you with A+ Precision Fabricated Felt Parts and also parts custom fabricated by us from all types of engineering materials. Send us your specifications and requirements, for our quotation. Our Engineering and Research Division, backed by over 60 years of experience, is ready to assist you in selecting or developing a material suited to your needs.

SEND FOR Technical Bulletins on the properties of A+ Wool Felts and FEUTRON® Synthetic Fiber Felts.

American Felt Company
[illegible] Glenville Road [illegible] Glenville, Connecticut



American Felt Company is A+ in
- SERVICE
- QUALITY
- ENGINEERING and RESEARCH

For more information, turn to Reader Service card, circle No. 496

RELAX!

It won't grow—or shrink or wear—it's Graph-Mo®—In twelve years of use, the master tapered plug gage in the picture above changed less than 10 millionths of an inch. That's stability—the kind of stability you get with Graph-Mo, one of the family of Timken® tool steels. ■ But stability is only part of the story when you use Graph-Mo. ■ Users report that Graph-Mo *outwears ordinary tool steels three to one.* It contains free graphite particles and diamond-hard carbides in its structure. ■ And users cut machining time and production costs. Graph-Mo is an oil hardening steel that machines faster and easier than ordinary tool steels. ■ You pay no more for all these Graph-Mo advantages. It costs no more than ordinary oil hardening tool steels. There is only one Graph-Mo and the Timken Company makes it. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

TIMKEN® FINE ALLOY STEEL

TIMKEN GRAPHITIC STEELS ARE AVAILABLE FROM STEEL SERVICE CENTERS IN MORE THAN 40 CITIES IN THE UNITED STATES AND CANADA

For more information, turn to Reader Service card, circle No. 331